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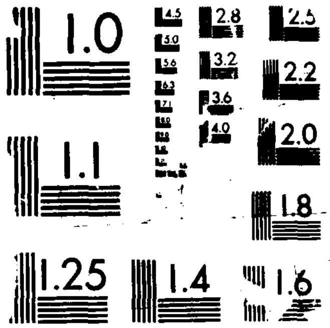

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A DEFINITION STUDY FOR IMPROVING INVENTORY CONTROL AND HANDLING FOR THE OVERHAUL FACILITY IN BUILDING 329 AT SA-ALC/MAT

FINAL REPORT
CDRL No. 2

Contract No. F41608-86-C-A016
SwRI Project No. 14-8917

Prepared for:

United States Air Force
Air Force Logistics Command
San Antonio Air Logistics Center
Technology Repair Division (MAT)
Kelly AFB, Texas 78241

Prepared by:

Automation and Data Systems Department
Southwest Research Institute

February 21, 1986

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~~MANAGEMENT REPORT FOR USE BY SA-ALC/MAT~~

Approved by:

Richard B. Curtin, Director
Automation and Data Systems Department

PREFACE

Southwest Research Institute (SwRI) is pleased to submit this final report covering the reporting period of October 31, 1985 to January 31, 1986 in support of contract no. F41608-86-C-A016. Receipt of this final report satisfies item two of the Contract Data Requirements List (CDRL No. 2) of the stated contract.

The contents of the report summarize the efforts of the SwRI project team to investigate and collect information pertaining to the control and handling of inventory within the Building 329 (B329) overhaul facility at Kelly AFB, TX. The major focus of the work centers on the development of a functional definition of a system that improves the handling, tracking, storage and scheduling of material throughout the overhaul process. The expected benefits of such an effort are the increased accuracy of production scheduling, the reduction of work in process (WIP) and increased visibility and accountability of inventory in storage.

This final report examines the observations and documents collected during the reporting period, proposes some initial ideas toward a conceptual system design and evaluates the impact of various design alternatives.

The SwRI project team would like to express its gratitude to all Kelly AFB personnel who provided their time and shared their experiences. Their information and insight into the workings of the industrial overhaul process within the depot proved to be invaluable.

SUMMARY

Analysis of the B329 inventory control and handling procedures revealed that significant benefits could be gained through the use of computer controlled mechanized storage equipment to organize and control parts storage functions, combined with an effective parts tracking system to monitor the movement of parts between facilities.

The ? ~~SwRI~~ project team conducted a number of personal interviews with various MAT shop personnel in order to gain an understanding of material routing procedures and functional duties associated with the B329 overhaul process. Being informed that the present parts pool location was to be relocated into a new area that was 30 % smaller, the team was tasked with conducting a functional definition of an inventory control and parts storage system for the new area.

In addition, the team investigated the requirement of a parts tracking system that would monitor the movement of materials within/and between the B329 facility. This required further evaluation into the existing part identification methods and procedures being used within the shop environment. Documents attached to parts take the form of embossed metal tags, paper work control documents and soon will also include laser etched metal tags for the new dimensional inspection system. (KR)

The conclusions of the definition study efforts stated that the future site of the parts pool would adequately provide the necessary volumetric storage capacity using horizontal carousel storage equipment. Recommendations were made to employ the use of a high powered mini-computer to perform the function of carousel control, inventory control and decision analysis utilities.

Pertaining to the tracking system, the team recommended that the existing Maintenance Job Tracking (MJT) system can be utilized, providing the following changes and conditions are incorporated; stabilization of system access priority, utilization of portable data collection units and improved support of the systems branch to provide adequate systems services for the users.

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1.0 INTRODUCTION

The San Antonio Air Logistics Center (SA-ALC) at Kelly AFB, Texas, is one of the largest industrial complexes located in the southwest portion of the United States. SA-ALC, being responsible for providing depot maintenance and overhaul for some of the nations most sophisticated aircraft and jet propulsion systems, utilizes various and complex industrial processes to support the mission of fleet readiness.

An overhaul facility housed in B329 at Kelly AFB is responsible for providing depot maintenance for 12 models of gas turbine engines (GTEs), 17 models of aircraft starters and 4 models of accessory drives, see Table 1. The facility is tasked with the production of approximately 1600 GTEs and 6000 starters per year.

Table 1
Model Numbers Overhauled in Building 329

GTE	STARTERS	MISC
36-50	100-87	L/H AMAD
85-56	100-89	R/H AMAD
85-70	100-97	JFS
85-71	100-138	CGB
85-72	100-176	
85-106	100-176A	
85-116	100-302	
85-180	100-325	
85-180L	100-395	
85-397	100-421	
165-1	100-422	
T41M9	CPS-01	
	CPS-02-MOD	
	CPS-07	
	CPS-09	
	CPS-11	
	CPS-12	

1.1 Backround

The overhaul process is comprised of a number of sub-proceses starting with disassembly, cleaning, inspection, repair, manufacturing, assembly and culminating with the dynamic testing of the completed unit. To accomplish the overhaul process, parts are removed, segregated, routed, collected, processed, sorted, stored, kitted and eventually converged to become part of a unit assembly.

The maintenance/overhaul environment places stringent requirements on the need to collect and report shop floor information pertaining to the locations and quantities of material in-process, inventory on-hand and estimated flow times for process completion. When accomplished in an accurate and timely manner this information proves to be invaluable in determining realistic production schedules.

A survey of the B329 facility and process reveals that the flow of information, tracking of parts and control/handling of inventory is accomplished in a strictly manual mode. This environment requires intensive utilization of shop personnel to move and handle material, identify and sort parts and record and maintain paper log (data) sheets in an effort to provide the information and visibility necessary for effective production management.

1.2 Scope of Work

Overall effectiveness of production scheduling is primarily affected by the timely tracking and status reporting of material in-process, strict control of part inventories, accurate accounting of inventory transactions and condemnations, efficient parts storage/retrieval methods, and availability of decision support utilities to assess contingency plans.

The major thrust of the contract is the development of a functional definition of a system that improves the handling, tracking, storage and scheduling of material throughout the overhaul process within B329. To accomplish this, the project team has focused on four separate topic areas:

- o Parts Storage
- o In-Process Parts Tracking
- o Inventory Control
- o Decision Support Utilities

It is the scope of this contract to functionally specify the conceptual design of a system to address each of these areas. The expected benefits of such a system are the reduction of work in process (WIP) staging buffers, an increased visibility and accountability of inventory in storage and the development of more accurate production schedules through the utilization of decision support utilities.

1.3 SwRI Program Structure

Southwest Research Institute (SwRI), an independent, non-profit applied research and development organization, has established a three layer organizational structure for the project team, designed to provide overall leadership and technical support. The three layers consist of: a) Program Manager, b) Project Manager and c) Technical Consultants.

The role of the program manager is to provide overall program guidance, technical direction and contractual monitoring. The project manager is tasked with the responsibilities of identifying problem areas,

invoking the aid of applicable technical consultants and establishing time/task schedules. As problem areas are defined, the project manager will confer with the program manager to select appropriate staff members to fill the roles of technical consultants. The consultants role is to provide a depth of experience and knowledge to a well focused problem description. As problems are addressed, the project manager orchestrates the smooth and orderly integration of potential solutions.

o	Program Manager	- R. Thompson
oo	Project Manager	- T. Der Tatevasion
ooo	Consultant - Material Storage	- L. Poirier
ooo	Consultant - Computer-Hard/Software	- D. Vickers
ooo	Consultant - Material Handling	- A. Rizo-Patron

1.4 Project Milestones

o Kick-Off Meeting - November 18, 1985 marked the formal kick-off meeting of the B329 Inventory Handling/Control definition study, which was held in the MATS branch office. First order of business was to identify points-of-contact (POC) within both organizations and lay the ground work for the information transfer that would take place. Refer to Appendix A for a list of attendees and POCs.

The balance of the meeting was spent firming up the scope of the study and identifying any roadblocks that could hinder the survey team in conducting its review. The basic discussion, pertaining to the scope, centered around the tracking of parts outside of the control of B329.

All agreed that parts tracking thru the backshops (Buildings 301, 324, 333, 348, 360 and 375) was a desirable feature, but due to the numerous building locations and personnel involved, such an undertaking would involve the coordination of all MA product divisions. This involvement would, no doubt, dilute the authority and possibly re-focus the program in a direction that might not address the MATS requirement. Everyone concurred that parts tracking outside of B329 would not be included under the scope of this study, but may be investigated at some future date.

A concern was aired that restricted access and communications between cognizant MAT personnel and the SwRI team would inhibit the necessary transfer of information. In response to this concern a portion of the B329 mezzanine office area was temporarily assigned to the SwRI team to be used as an office. Also, action was taken to obtain three controlled area badges, to be provided to the team in order to facilitate the survey and information collection process.

- Interim Report Review Meeting - The interim report covering the reporting period of October 31, 1985 to December 20, 1985 was delivered to the MATS branch office on January 16, 1986. The interim report highlighted the observations, facts, documents and drawings collected during the reporting period and proposed some initial ideas toward a conceptual system design.

  Review meetings were conducted at Kelly AFB between January 21-29, 1986 to review the contents of the report and to evaluate the progress made. Of particular concern to the projcet team was obtaining feedback from MATS personnel on the validity and accuracy of observations noted. The general consensus was that the information contained in the report was factual and accurately represented the procedures and policies currently being used within the B329 facility.

  The two main points discussed during this review period pertained to the Parts Pool (PP) layout requirements and the parts tracking system:

  PP Layout Requirements:

  An evaluation and analysis of the four layout drawings (No. SK-001 thru 004 included in the interim report) resulted in further refining of the PP layout requirements to include less core storage volume, more tote routing stations and better aisle design. Drawing numbers SK-005 thru 007 reflect these additional requirements. Refer to section 2.3.1.4 for an in depth discussion of the layout requirements and new drawings.

  Parts Tracking System:

  The majority of discussion centered around the observations that were recorded in the interim report pertaining to the parts tracking system. The report stated that the existing Maintenance Job Tracking (MJT) tracking system possessed the necessary attributes to once again become a viable tracking system.

  Rather than propose another means of part tracking and inevitably another part tagging scheme, the project team suggested that the MJT system be studied in greater detail. This suggestion was followed and a further investigation into MJT was conducted in three meetings during the report review period.

  A majority of attendees agreed that MJT could be used as the principle system for parts tracking if certain provisions were made to (1) reduce the number of parts tracked to critical items only, (2) minimize requests for interrogation transactions, (3) utilize portable barcode readers for data collection, (4) cleanup and purge old job requests choking the MJT host and (5) establish a link between the MJT host and the parts pool computer for the downloading of tracking data. Refer to section 2.4 for an explaination of the provisions required of the MJT system.

2.0 SUBJECT REVIEW

The team interviewed numerous personnel (refer to Appendix A) in an attempt to understand and document the various topics, policies and methods used within the Technology Repair division (MAT) to manage the tracking and control of parts within B329.

An initial interview was conducted with Mr. Pete Cubellis, MATSM, (subsequently transfered out of MAT as of January 1986), for the purpose of completing the Initial Survey Checklist (Appendix B). The checklist proved to be a useful vehicle for establishing a starting baseline for the study. The project team used the checklist responses to direct their efforts and questions for the following interviews that were conducted.

During the course of the investigation numerous documents and drawings were received by the project team to aid in the transfer of information and the establishment of an understanding of the overhaul process and associated support systems. A complete list of documents that were received by the project team is located in Appendix C.

The inventory control and handling study was divided into five subject areas to promote the ability of the review team to focus in on the efforts of the investigation. Following the completion of the interviews, the information and facts gathered were segregated into one of the following five subject areas:

- Material Flow
- Parts Identification
- Parts Pool Storage
- Material Control System
- Computer Control System

All subject areas relate to a particular portion of the overall project scope, and are summarized separately in the sub-sections that follow. Each subsection reviews the observations and facts collected, makes note of any concerns and where applicable suggests potential feasible solutions to address any observed or perceived deficient conditions.

2.1 Material Flow

Understanding the dynamic factors involved with the flow and routing of material is vital when designing a system that will control the tracking, handling and accounting of material. A basic understanding of material flow paths was established which allowed the project team to identify bottleneck areas and choke points within the existing shop layout.

The present shop layout of B329 is shown in Figure 1. The east portion of the building is responsible for unpacking, disassembly, cleaning, inspection, painting, parts pool storage and accessory assembly while the west portion is comprised of sheet metal and electrical shops, Material Inventory Control (MIC) and GTE/Starter assembly shops. The center aisle of the building which separates the MIC from the parts pool is the main route for material pickup and shipping.

2.1.1 Observations

Initial conversations with MATS personnel indicated that the flow paths for material/parts movements within the B329 facility were very intricate and complex. The first attempts to generalize part flow paths resulted in the generation of a simplified high level flow diagram as depicted in Figure 2. This high level flow diagram identified eight major nodes within the flow network:

- o Disassembly
- o Cleaning (B329)
- o Evaluation/Inspection
- o Parts Pool Inventory
- o Buffer Storage
- o Back Shop Routings
- o Assembly
- o Test Block

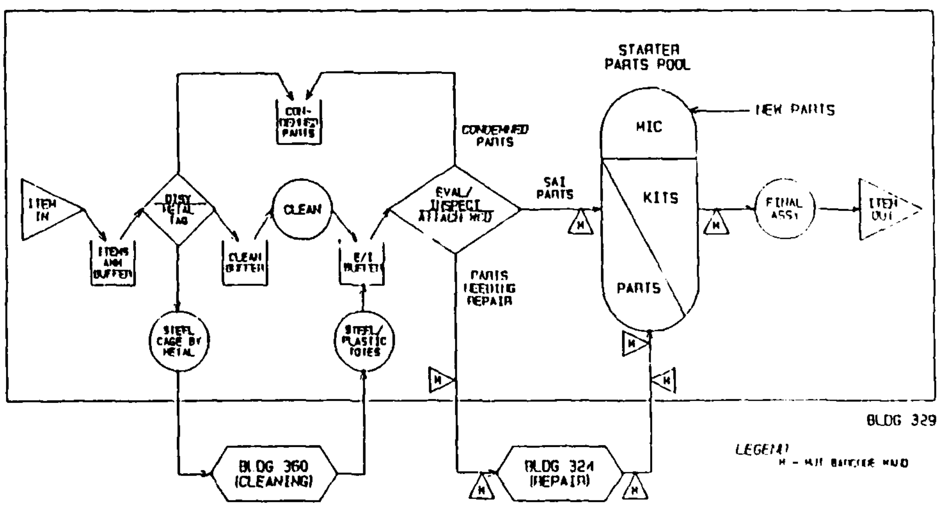
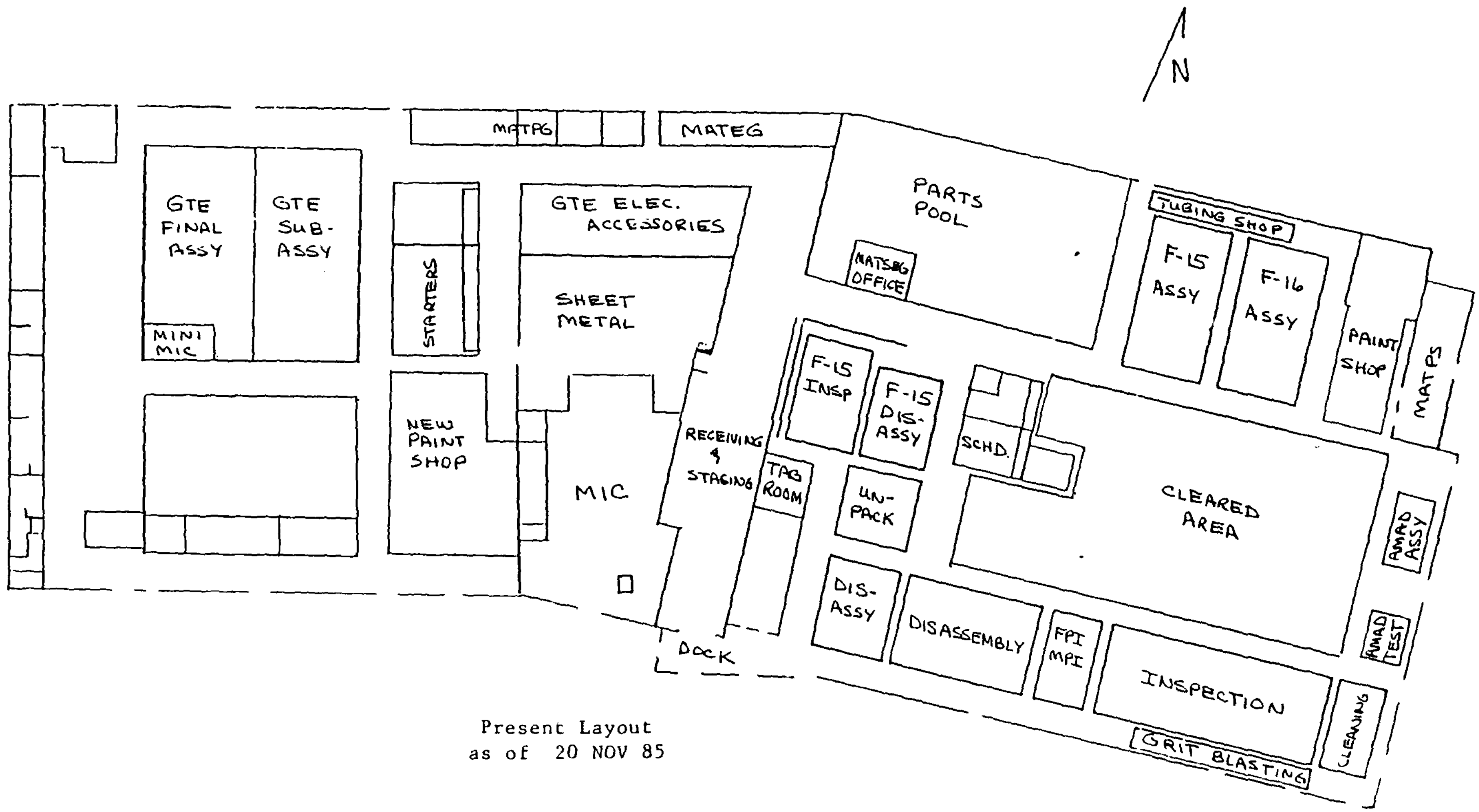


FIGURE 2. Parts Flow Diagram - Simplified



Present Layout
as of 20 NOV 85

FIGURE 1. B329 Present Shop Layout

While essentially correct, the simplified flow diagram did not offer the level of detail necessary for effective flow analysis. The team concluded that a detailed flow diagram was required to represent factors such as conditional branching and nodal relationships. These efforts resulted in Drawing No. SK-8917-008 which depicts parts flow on a level of detail much greater than the initial simplified diagram.

The following paragraphs provide additional insight into the flow of parts as represented in SK-8917-008.

2.1.1.1 Input

Items (GTEs and Starters) are sent from the Directorate of Distribution (DS) warehouses to B329 for overhaul and repair. GTEs are received in a fenced in storage yard, outside of B329, and wait there until receiving calls for them. All other items route directly from the warehouse to B329 receiving.

2.1.1.2 Receiving

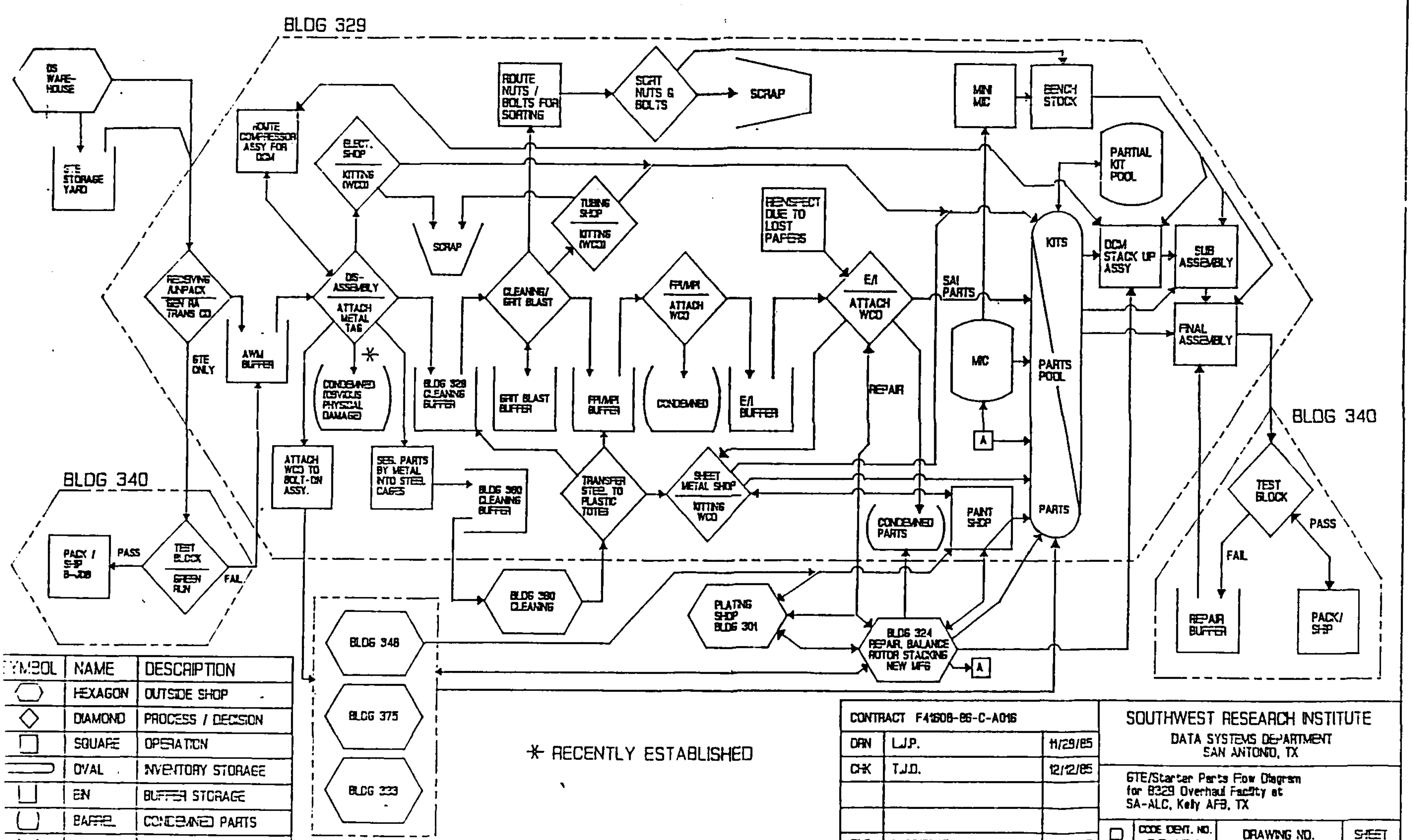
Items are unpacked and are staged for disassembly. An RA transaction card is generated to acknowledge receipt of the item to the D033 (base supply) data system, which in turn logs to the G004L data system that the item has been inducted into the overhaul process and is on-work-order (OWO). After unpacking, personnel will look over the item and check for obvious physical damage (OPD) and missing components. If missing components are noted a material requisition, form 244, will be generated under cost code "M" which will request a replacement part from the base supply system.

If the item is a GTE unit and it appears to be in very good condition, receiving may elect to send it to the test block for a Green run (GTEs only). If the GTE passes the test block then a decision can be made to ship the item out as a servicable asset, in which case MAT would report the job as a B-Job (partial job). If the GTE fails the test block then the item is staged in the awaiting maintenance (AWM) buffer.

2.1.1.3 Disassembly

Disassembly pulls items from the AWM buffer and starts the teardown process. As parts are removed they are identified using a "picture book" and are tagged with the appropriate metal tag containing pertinent information of the end item and job number (refer to Section 2.2.1.1 for an explanation of this tag). The "picture book" contains photographs of every part used on an end item. Each photo depicts all of the parts contained in a single plastic tote and is commonly refered to as a "kit". The average GTE consists of between 8 to 13 photos or kits, while a starter has 1 or 2 photos representing kits.

The disassembly function acts as a divergence node to route parts throughout the process. Parts routing includes:



SYMBOL	NAME	DESCRIPTION
	HEXAGON	OUTSIDE SHOP
	DIAMOND	PROCESS / DECISION
	SQUARE	OPERATION
	OVAL	INVENTORY STORAGE
	BIN	BUFFER STORAGE
	BARREL	CONDEMNED PARTS
	BUCKET	SCRAPPED PARTS

CONTRACT F41608-86-C-A016		
DRN	L.J.P.	11/29/85
CHK	T.J.D.	12/12/85
FILE	SK8917005	12/13/85

SOUTHWEST RESEARCH INSTITUTE
DATA SYSTEMS DEPARTMENT
SAN ANTONIO, TX

GTE/Starter Parts Flow Diagram for B329 Overhaul Facility at SA-ALC, Kelly AFB, TX

SIZE	CODE IDENT. NO.	DRAWING NO.	SHEET
B	26401	SK-8917-008	1 OF 1

- Bolt-On Components - These components include fuel controls, oil coolers, oil pumps and radiators that are sent to outside shops (i.e., B333, B348 or B375) which perform overhaul and repair functions on the components. Before the component is routed to these outside shops, a Work Control Document (WCD) is attached to the part which contains detailed routing instructions. These outside shops perform their processes and route the components back to the B329 parts pool for inventory storage.

- GTE Compressor Rotor Sub-Assembly - Prior to these sub-assemblies being disassembled, they are sent to the stack-up assembly shop as an On-Condition-Maintenance (OCM) candidate. The OCM team evaluates the condition of the rotor and determines the level of work required to repair the unit. In some cases the rotor assembly may have sufficient life remaining that it can be built up into a GTE engine assembly. In other cases it will be returned to disassembly for further teardown and inspection. These assemblies are routed without any routing documentation attached.

- Electrical Parts - Electrical parts are placed in totes, a routing list is attached and the tote is sent to the electrical shop for processing. The electrical shop cleans, repairs and builds up an electrical kit that is sent to the parts pool for kit storage.

- B329 Cleaning - A number of parts stay within B329 for cleaning. These parts are placed in totes and are staged in the B329 cleaning buffer.

- B360 Cleaning - Parts are segregated by metal type (aluminum, stainless steel, magnesium, etc...) and placed within steel cages that are routed to B360 for de-greasing and cleaning. Upon returning from B360, parts are transferred from metal cages into totes which are dispersed either to the B329 cleaning buffer for further cleaning, the inspection buffer to await Flourescent Penetrant/Magnetic Partical Inspection (FPI/MPI) inspection or the sheet metal shop for processing. A large number of parts that return from the B360 shop are routed to the B329 cleaning shop for further processing.

- Part Condemnation - Parts with OPD conditions can be condemned in disassembly only after an inspector or a shop planner have reviewed the parts condition. After the parts are evaluated they are routed to a caged staging room to await further dispositioning. This procedure has just recently been established in the disassembly shop to reduce the time required to report condemned items and receive servicable replacements. Under the guidance of the shop planner, if the condemned parts are complex geometries or made of strategic materials then they may be sent to a temporary holding account (K account) to await future evaluation or the development of new repair processes. Refer to section 2.1.1.5 for further insight into the handling of condemned parts.

2.1.1.4 Cleaning

Various cleaning and grit blasting functions are provided within B329. The cleaning shop pulls totes from the cleaning buffer and processes them using a number of cleaning methods. Following cleaning, some parts may require grit blasting. These totes are staged in the grit blast buffer. All tubing parts are routed to the tubing shop after cleaning. The tubing shop inspects, scraps and builds up tubing kits, which are sent to the parts pool for storage.

Cleaning also receives plastic bags of nuts and bolts that are bagged during disassembly. These piece parts are cleaned and sent to an area in the shop for manual sorting, which eventually feeds the bench stock in the assembly areas. Piece part sorting times could be substantially reduced by using currently available industrial sorting equipment which uses an array of ultrasonic sensors to rapidly identify and divert work pieces into appropriate bins.

A large percentage of the parts going through B329 cleaning are routed to the FPI/MPI buffer. Parts pulled from the FPI/MPI buffer are inspected using either FPI or MPI methods, and a determination of the part condition is made. At this node parts are either condemned or moved on to the Evaluation/ Inspection (E/I) buffer for more extensive inspection.

2.1.1.5 Evaluation/Inspection

The E/I node is perhaps the most critical node in affecting the flow of parts to the repair shops. E/I performs visual and dimensional inspections on parts in accordance with appropriate Technical Order (TO) inspection criteria. After a part has been inspected a WCD is attached to the part which details the processing steps required (Refer to Section 2.2.1.2 for an explanation of WCDs). The inspector is then required to assign the part into one of three categories:

- Satisfactory-As-Is (SAI) - Parts in this category have passed all inspections and can be reused in their present condition without further processing. These parts are directly routed to the parts pool for storage.

- Repair - These parts require additional processing to restore and repair worn areas. Typically the majority of parts requiring repair are routed out of B329 and into the machine shop B324 for further processing. The actual physical movement of parts is accomplished using a truck/train service that picks up and drops off totes between the two buildings at predetermined times.

  There are four primary tasks performed by B324; repair, balancing, rotor stacking and local manufacturing. Local manufactured parts are routed either to the B329 parts pool or the MIC, while rotor stack ups flow directly to the parts pool for storage. Part machining and repairing is accomplished in a collection of smaller shops within B324 that perform numerous machining/repair operations on parts such as:

- Welding
- Brazing
- Heat Treating
- NC Manufacturing
- Sheet Metal
- Machining
- Metalizing
- Grinding

The Directorate of Maintenance (MA) relies on this shop to support its three product divisions (MAB, MAE and MAT). Since the machine shop is a multi-customer service organization, it is faced with the following types of problems:

- Work order prioritization
- Shop capacity utilization
- Parts tracking
- Material handling
- Work order routing
- WIP storage

Acting as the focal point for part repair, parts undergo processing within B324 which can then be subsequently routed to other buildings (i.e. B301, B333, B348 or B375) for more specialized processing. Realizing the intricate and complex part movements that occur outside the confines of the B329 overhaul facility, production planners are faced with the challenge of accurately predicting part processing flow times thru the backshops.

o Condemned - Condemnation can ocurr at any of four locations; disasembly, FPI/MPI, E/I or the machine shop in B324. Parts with conditions that exceed servicable T.O. limits can be handled in two ways, by either attaching a 'Green' or 'Red' material action tag to the part.

A 'green' tag attached to a part requests the assistance of a shop planner to review and evaluate the condition of the part and make a decision as to whether the part should be used as is, sent to a holding warehouse (K-account) to await the development of a repair procedure or condemn the part and obtain a replacement.

A 'red' tag attached to a part indicates condemnation. In either case these parts are routed to a condemnation holding cage which is currently located near the MIC in B329. If a part is condemned a 244 card is generated which is a material requisition for obtaining a replacement part form the MIC.

2.1.1.6 Buffer Storage

Table 2 is a snap shot of buffer sizes as of November, 1985, representing the number of totes stored in various buffers throughout B329. The two most significant buffers are located in the B329 cleaning shop and in E/I.

TABLE 2
Building 329 In-Process Buffer Sizes

Buffer Storage Area	No. Totes
B329 Cleaning	550
Grit Blast	170
FPI/MPI	50
E/I	570
Paint Shop	120

It appears that it is difficult for these two shops to maintain enough capacity to keep up with the tote generation rate. The following points offer an explanation as to why these conditions exist:

- Non-Essential Parts Input: Frequent part shortages are being experienced in the overhaul process due to the unavailability of parts from the MIC (base supply system). Management has been surviving by inputting more end items into the system in order to generate the required critical parts needed to meet production schedules. This policy results in saturating the process shops (i.e., cleaning, E/I, B324, parts pool, etc...) with totes that contain parts that are not essential to meet production schedules. Parts are termed non essential if they are generated from an end item that was input into the system due to the need for specific critical parts (i.e., T-wheels, bearings, etc...).

  As the buffer sizes grow totes are stacked one on top of each other. This makes it very difficult for shop personnel to sort thru the totes and identify contents. A point is reached in which the shop foreman looses visibility of the parts within the buffers and is no longer effective in setting job priority and selectively scheduling jobs to be worked. A survey of the age of jobs waiting in the buffers indicating some job tags dating back to 1984.

- Shop Capacity: Analysis of the parts flow process reveals that the disassembly appears to have no problem in keeping up with the item input rate. Estimated disassembly times were quoted by shop personnel as being 5 hours for a GTE and 2 hours for a starter. In order to address the bottleneck nodes, MAT management has two major initiatives underway. A new automated inspection system (MSAPIS) is planned for installation by late 86 to mid 87 (see Section 2.2.1.3 for information on this system), while a new cleaning line is currently being designed and is projected for procurement in mid 87. Refer to Appendix E for references to the dates quoted.

2.1.1.7 Parts Pool Storage

The parts pool (PP) is an inventory storage area that has two main functions, 1) receive and store parts and 2) build and ship kits. Note: Section 2.3 of this report covers the parts pool storage area in much greater detail. This node acts as the major convergence point in the overhaul process for parts being received from the following locations:

- o E/I (SAI parts)
- o MIC (new parts)
- o Paint Shop
- o Sheet Metal Shop
- o Repaired Parts (B324)
- o Local Mfg. Parts (B324)
- o Bolt on Accessories (B348, 333 & 375)
- o GTE Rotor Stackups

Parts arrive into the PP area either by overhead monorail, hand carts or train service. As parts are received they are stocked in conventional shelving using the plastic totes. The PP area is divided into two sections, Starter parts and GTE parts. Personnel are assigned to one of the two areas.

Kits are built by selecting parts and placing them in a tote. Kit contents are recorded in the "picture book" corresponding to the type and model of end item that the kit is being built for. Kit assembly times range from 45 minutes to 1 hour. Within each of the two areas is an area designated for kit storage. The kit storage areas can receive kits from the following shops; Electrical, Sheet Metal and Tubing shops as well as those generated in the PP. Issues from the PP come out in the form of tote kits which are sent to the assembly shops according to production schedules.

2.1.1.8 Assembly

End items are assembled in three basic stages; 1) Stack up, 2) Sub-assembly and 3) Final assembly. The parts pool supplies kits to each stage of assembly. The nuts, bolts, washers, o-rings, etc that are used during assembly are supplied from bench stock which is fed by two sources; the mini-MIC and reclaimed piece parts (nuts, bolts, washers only).

The stack up assembly stage receives balanced compressor rotors direct from B324. As noted previously, OCM evaluations are performed on compressor assemblies that are removed from GTEs during disassembly. After an item is completely assembled, it is sent to the test block in B340 for test.

2.1.1.9 Test Block

The test block dynamically tests the functionality of each item. The run cycle is controlled by a computer which adjusts key engine controls based upon an approved T.O. test procedure. If engine parameters fall outside of acceptable limits then the engine fails the test run and a troubleshooting procedure is used to identify potential problems or mis-adjustments. In severe cases the item may route back to final assembly for part replacement. Upon successful completion of a test run, the item is packed and shipped to the DS warehouse, thus completing the overhaul process.

2.2 Parts Identification

Proper identification of parts using tagging or marking methods allows data collection equipment (i.e., barcode readers, magnetic strip readers, surface acoustic wave receivers ...) to rapidly and accurately identify pertinent part information, with minimal touch labor. The following paragraphs discuss part identification and data collection methods currently being used within the B329 facility.

2.2.1 Observations

The two principal part tagging methods used are; metal tags and paper Work Control Documents (WCDs). Metal tags are attached to parts to provide gross identification while the part is subjected to harsh process such as chemical cleaning and/or grit blasting, while the WCD provide a more rigourous means of part identification and also acts as a routing document and process sheet.

2.2.1.1 Metal Tags

As an item is received from the warehouse and brought into the building for unpacking, metal tags are ordered from the Tag room by the disassembly foreman. The foreman keeps track of the item Model/Design/Series (MDS), induction date and job type and relays this information to the tag room for tag production. The metal tags are stamped out using an address-o-graph embossing machine. Tag production is performed far enough in advance so that by the time the item reaches the disassembly shop, the tags are ready to be attached to parts (with wire) as they are removed from the item.

The format of the present metal tag is shown in Figure 3. The production number, which is a combination of control number and job designator, is used by shop personnel to charge labor hours expended, while the job designator indicates the type of job (i.e., A = overhaul, B = minor repair and C = modification). The Job Order Number (JON) provides a breakdown of the cost period for a given production number.

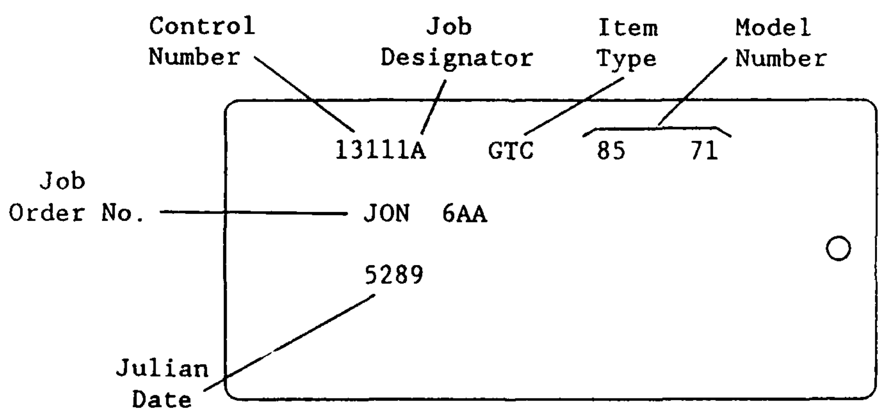


FIGURE 3. Metal Tag Format

2.2.1.2 Work Control Documents

The WCD is a multi-function document that performs three main functions; 1) part identification, 2) routing list and 3) process sheet. WCDs are placed into plastic pouches and are attached to parts at numerous locations along the process. Bolt-on accessories (fuel controls, oil coolers/pumps, radiators ...) receive WCDs while in disassembly. Electrical, tubing and sheet metal parts receive WCDs while in their respective shops. The remaining bulk of parts receive WCDs while in the Evaluation/Inspection stations.

WCDs contain large amounts of part specific data. The document length can range from one page to many pages depending upon the complexity and number of operations required to process the part. Appendix D contains an assortment of sample WCD documents that can be used as references. The field format of a WCD is shown in Table 3. This is a fixed format which is used throughout all depots under the Air Force Logistic Command (AFLC).

TABLE 3
Work Control Document Format

Field No.	Pre-Printed Field*	Field Name	Field Description
1	Y	DATE	WCD revision date
2	Y	ORIG/PROD NR	Production Number
3		QUANTITY	Qty. of parts covered
4	Y	PRODUCTION SECTION/RCC	Reporting Cost Center
5		DATE SCHEDULED	
6		DATE COMPLETE	
7	Y	PART NUMBER	
8	Y	TECH DATA	T.O. References
9		ITEM SERIAL NR	
10	Y	MODEL/DESIGN/SERIES	
11	Y	STOCK NR	National Stock Number
12	Y	OPTIONAL	Barcode Symbol, Matl
13		MISC	
14	Y	NOUN/END ITEM NOUN	Part Description
15	Y	DISP-STATION	Dispatch Station
16	Y	PDN/OP NO.	Shop Symbol/Operation #
17	Y	WORK TO BE ACCOMPLISH	Work Description
18		MECH	Mechanic Stamp
19		P	Production Stamp
20		Q	Quality Stamp

*These fields are pre-printed on WCD and are not a required entry for each part.

A unique part numbered item may have more than one WCD associated with it. For example, a turbine wheel could have a number of different repair procedures that pertain to different areas on the wheel (i.e., blade tip, blade airfoil, root radius, wheel face, etc...). A WCD is identified by the production number that is printed in field 2 of the format. This production number can be used to reference labor standards for the operations listed on the WCD.

Changes to WCDs are accomplished using a coordination team comprised of representatives from planning, scheduling, quality and engineering. If a new procedure is to be added to process a part then the coordination team will determine the operations and sequence of steps, establish a labor standard and assign a production number. ,

The majority of WCDs contain a barcode symbol in field 12 of the document format. This code is used by the Maintenance Job Tracking (MJT) system to identify parts and track their movement within various overhaul facilities. The symbol contains a six digit number that is encoded IAW the DOD LOGMARS code 39 standard barcode format. The number is assigned using the MJT computer system. Refer to section 2.4.1.1. for additional information regarding the use of the barcode field and its importance to the MJT system.

The six digit barcode numbers are assigned by the MJT system to each unique set of data consisting of 1) P/N, 2) NSN, 3) Noun and 4) Production Number. Upon entry of a request for a barcode number, the MJT system reviews the database for duplications and assigns a new number if the part identification data set is unique. In essence, MJT maps this six digit number to the four pieces of part identification information in its database.

It is important to note that the six digit number encoded in the barcode symbol is relevant only to the MJT tracking system. Not all WCDs contain a barcode symbol, due to the fact that MJT was not set up to track every part, but rather only those parts determined by the coordinating team to merit tracking.

Upon assignment of the number, a barcode label is produced and is mounted in field 12 of the master WCD. When the master is complete, color copies are run off and are distributed to appropriate shops. Color coding of WCDs is used to match WCDs to general categories of item types. The color coding scheme used for items within B329 is shown in TABLE 4.

TABLE 4
WCD Color Coding Scheme - B329

COLOR	ITEM TYPE
White	Starters
Green	GTE
Lt Blue	F-15 SPS

Every part, while in the overhaul process, must be tagged (metal or WCD) at all times. In the event a part loses it's tag or WCD, procedure dictates that the part be routed back to E/I for inspection. This is to ensure that parts do not bypass critical process steps such as inspection, evaluation or repair.

2.2.1.3 Laser Etched Metal Tags

A new inspection system termed the Multi Station Auto Prompting Inspection System (MSAPIS) is being developed under a government contract by L&K Tools for the MAT division. The system will implement 20 automated dimensional work stations which will be used to inspect and evaluate various part geometries and dimensions. Delivery of the system is expected in two phases;

28 MAY 86 Phase I - Partial installation of the host system, laser etching equipment and four inspection work stations.

25 SEP 86 Phase II - Installation of balance of work stations.

The auto prompting feature of MSAPIS will display a WCD on a CRT screen for operator viewing. WCD documents will be printed out at the inspection station on command and should effectively eliminate the shelves of WCDs that are presently required to store the printed copies.

The host computer system will consist of two DEC VAX 11/780s which will be dedicated to the control of the MSAPIS system. Current plans do not include establishing communication interface links between the MSAPIS hosts and any other computer system.

Each part entering the inspection cell will have a metal tag attached that contains a laser etched barcode symbol. Metal tags will be ordered and attached to the parts during disassembly, similar to the present tagging process. Only those parts requiring a visual or dimensional inspection will be tagged with the laser etched barcoded tags.

The laser tags will contain much more specific part information than is stamped on the present metal tags. A barcode symbol representing the part number will be etched on the tag IAW the DOD LOGMARS code 39 barcode format. Additional part information will be etched in alpha/numeric characters. The proposed format for the laser etched tags is shown in Figure 4. The fields marked with an asterisk indicate that it is undergoing evaluation to determine the use and benefit of using the information.

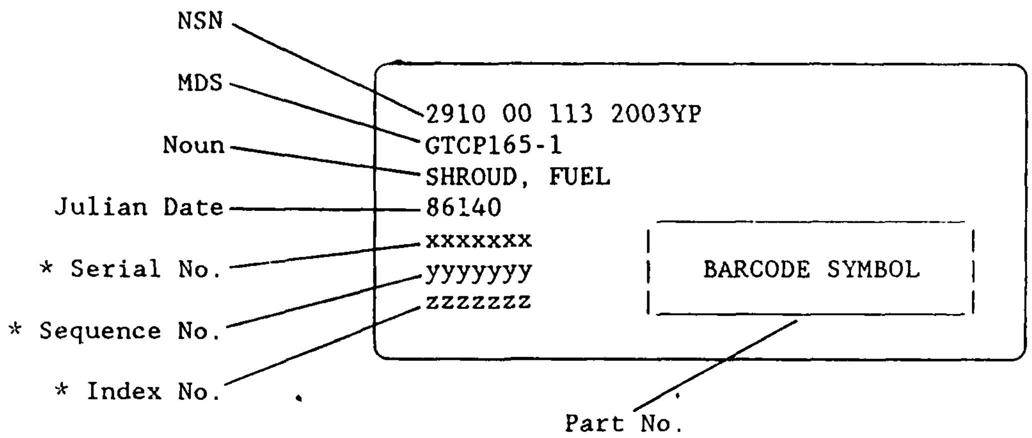


FIGURE 4. Proposed Laser Tag Format

The MSAPIS program will upgrade the tag room from address-o-graph machines to laser etching barcode equipment. The expected capacity of the tag room is to produce approximately 400,000 laser tags/yr. Tag production is estimated to run between 25 - 35 seconds. The laser tagging equipment will be controlled by an IBM PC which will contain a database of part information arranged by GTE/starter type. It is understood that no external communication links are planned for the IBM PC laser etching control computer.

Although the MSAPIS is a completely stand alone, dedicated system, it appears that it has the potential of providing WIP tracking status information of parts within the inspection work area. From this point it may be worthwhile to establish a communication link between the MSAPIS system and any future parts pool inventory control system, to provide the status of parts within inspection.

2.3 Parts Pool Storage

The parts pool (PP) storage center located in B329 is the main inventory stocking point for serviceable GTE/Starter parts. The PP is tasked with two main functions; 1) receipt and storage of parts, and 2) building and shipment of kits to assembly shops. The transformation of parts into kits utilizes the resources of four basic types of parts that are received by the PP, these include parts that are; SAI, repaired, local manufactured and new parts from the MIC.

2.3.1 Observations

Figure 5 highlights the present and future location of the PP storage center. The relocation of the PP into the new area is expected to occur early in 1987. A gross analysis of this figure reveals that the future PP area will have a footprint that is approximately 35% smaller than the present location, but will be required to handle the same amount of material as is being handled in the present PP area. This reduction in storage space requires that various means of material storage be investigated and evaluated in order to increase the density and efficiency of parts storage/handling.

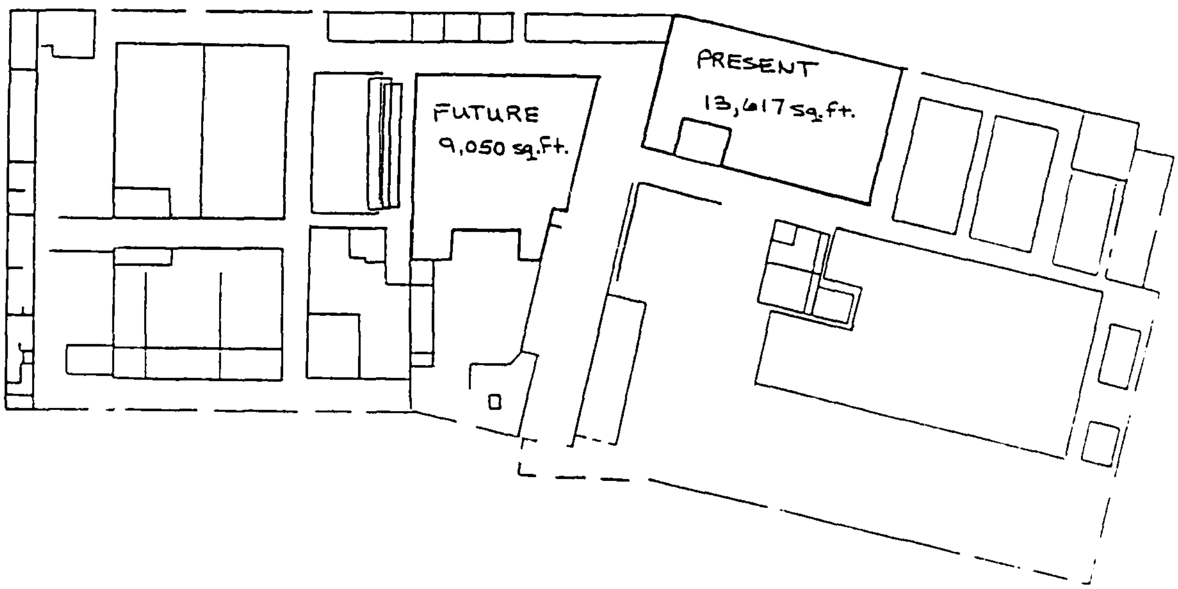


FIGURE 5. B329 Parts Pool Locations

2.3.1.1 Present PP Layout and Operation

The present PP area is comprised of approximately 13,617 sq. ft. of floor space which provides storage in excess of 5,000 three cu.ft. plastic totes. Figure 6 represents the layout and distribution of parts/kits stored within the PP. The area is roughly divided into three sections; Starter parts, GTE parts, and CGB parts. Within each of these three areas totes are further segregated and stored by item model number.

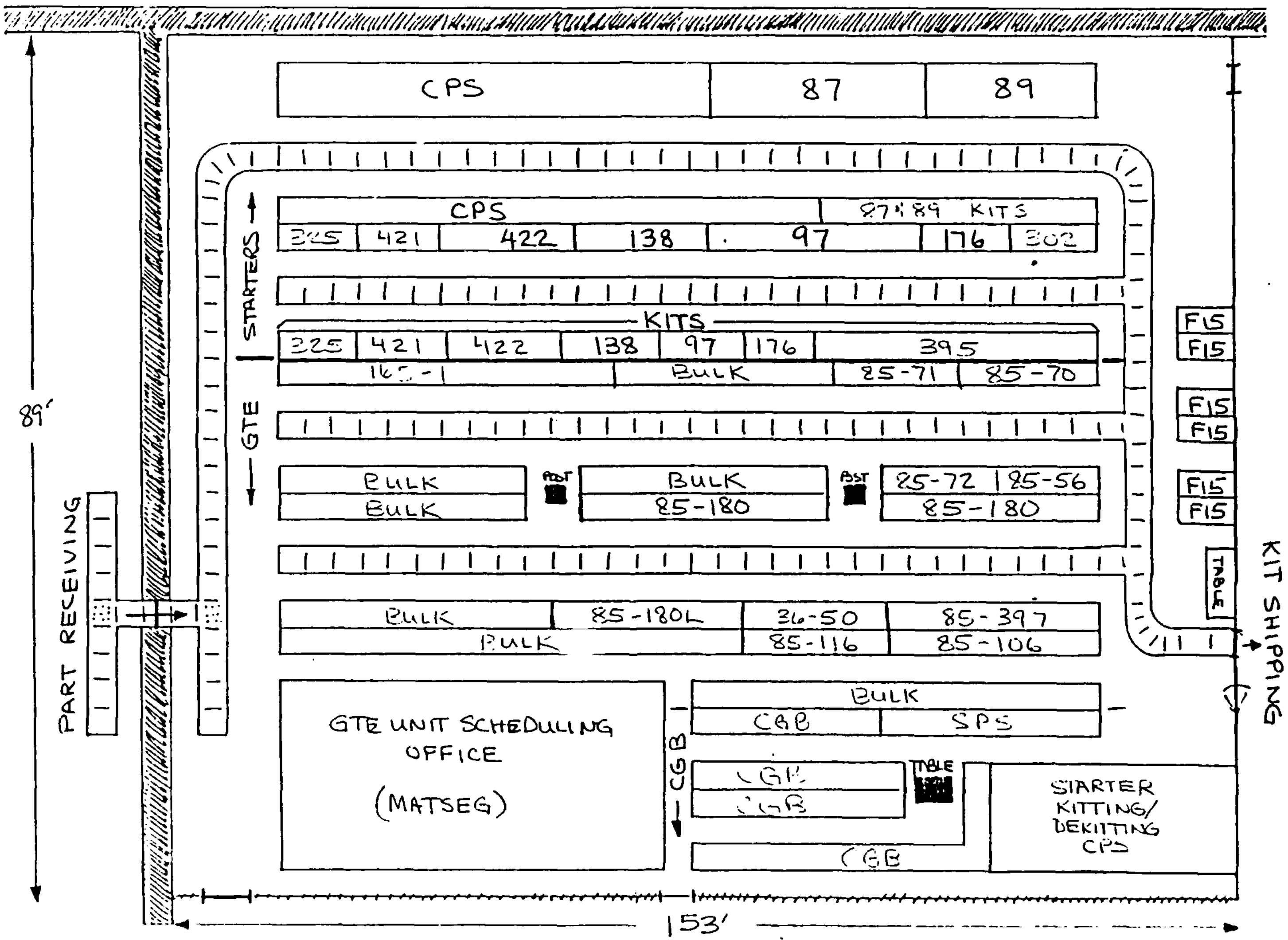


FIGURE 6. Parts Pool Layout - Present

Parts arrive in totes and are placed on a conveyor which sends the totes thru a wall into the parts pool area. The totes may contain more than one part type (i.e., spur gears, pinion gears, etc...), or may contain quantities of a single part type. The policy is that all parts must be received with a WCD attached to the individual part. The team observed totes with quantities of a single part type that did not have a WCD attached, instead a stack of WCDs for the parts were placed in the tote but not attached. It is not known which shop originated this technique or why it is being used or tolerated.

As the totes queue up on the receiving conveyor they are manually segregated and moved into three locations; totes which contain GTE parts, totes with CGB parts and totes with starter parts. The color of the WCD aids in performing tote segregation. After the parts in a tote are identified the tote is moved along the conveyor and sent to the appropriate section. The receiving rate of totes is not continuous but tends to be sporadic in nature. This may be due to the method of transportation used to move totes from the B324 repair shops and E/I inspection area (e.g. train service and push carts).

After the totes have been moved into their respective areas personnel select totes and route then down the appropriate roller conveyor until the appropriate shelf and bin is located for the part to be stored. The parts are removed from the tote while on the conveyor and are placed in the tote which is stacked in the shelving. This action is performed manually since tote weights tend not to exceed 50-55 pounds and the tote size is fairly manageable. Parts range in size from cubic inches to a maximum of two cubic feet.

The shelving system is completely manual and consists primarily of open frame tote box holders and steel shelf units. A conventional cube matrix approach is used to indentify part/tote locations. Figure 7 depicts this method of indexing shelf locations.

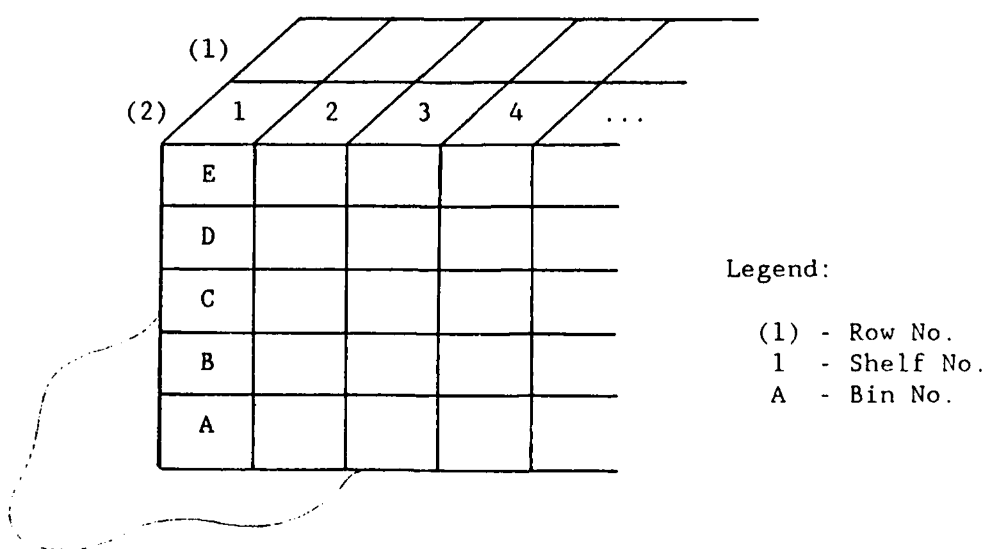


FIGURE 7. Parts Pool Shelf Indexing Method

At the end of every row of shelves is a clipboard that contains a document called a shortage sheet is attached. The purpose of this document is to keep a running inventory of the parts listed and to highlight part shortages that are holding back the shipment of kits. The shortage sheets are used by the 'Parts Busters' group whose duty it is to order and follow up on the procurement of the critical parts.

Frequent manual inventory counts of the PP are performed each month to adjust inventory levels on the shortage sheets. The current inventory policy is to maintain atleast a two week backlog of parts in the PP.

The kitting function is essentially a one man operation. Using the "picture book" as a guide, parts are selected and assembled into a kit IAW the parts shown in the kit photographs. Since parts are stored by MDS (model) designation they tend to be located in close proximity to one another, which in turn promotes kitting.

Typically a GTE will consist of between 9 and 14 tote/kits while a starter will consist of 1 or 2 totes. Kitting times range from 30 minutes to 1 hour. These times are highly dependent upon the proficiency and experience of personnel performing the job. At the time the PP was surveyed, very few GTE kits were stored in the PP, while on the other hand starter kits consumed a row of shelves for kit storage.

The PP area requires a work force of 30 personnel which are divided into two groups; 13 in the GTE group and 17 in the starter group. Each group is controlled by a group supervisor who has the responsibility for issuing the daily work requirements and priorities to meet production schedules.

Parts pool personnel serve in multi-functional capacities with duties that include receiving, stocking, logging, kitting, issuing and expediting material. Approximately half of the total PP work force are assigned expediting duties outside of the PP area.

2.3.1.2 PP Throughput Capacity

An analysis of throughput capacity for the parts pool was conducted to quantify the average number of totes/baskets that arrive and are issued from the PP. Prior to the analysis being performed, certain assumptions had to be stated.

These assumptions were established under joint agreement between MATS personnel and the project team. Items A - F listed in Table 5 show the values that were assumed to support the throughput calculations. A description of each assumption should help to define how the results were derived.

o Assumptions:

A - Yearly Production Units = i/y
Defines the average number of items (GTEs and starters) that are overhauled on a yearly basis.

B - Average No. Parts/Item Units = p/i
Gives the average number of parts for an item. This does not necessarily include bench stock parts such as o-rings, nuts, bolts, washers, etc.

C - Work Days/Year Units = d/y
This number is the difference between the number of week days in a year (260) less holidays (10) less normal days associated with vacation and/or sick leave (10).

D - Work Hours/Day Units = h/d
This number is the difference between the duration of the standard work day (9 hours) less time for lunch and breaks (1 hour).

E - Average No. Parts/Totes Units = p/t
This quantifies the average number of parts that are contained in totes that are received into the parts pool for stocking. The source of these totes will be the E/I shop, machine shop (B324), other back shops and the MIC.

F - Average No. Baskets/Item Units = b/i
This relates to the average number of baskets it takes to assembly an item. In other words, the average number of baskets required to be sent from the parts pool into assembly in order to build an item.

Rows G and H contain the results of the calculations using the values listed in Table 5. The foumulas that were used to perform the analysis are listed below Table 5 and were constructed using the item designator listed in the left hand column of the table.

The result of the analysis indicate that an average of 32 totes/hour arrive into the parts pool while an average of 17 baskets/hour are issued from the parts pool. In this case a tote and a basket are one in the same but for purposes of consistency, the term basket was used to indicate outgoing totes because this is what the shop personnel are familiar with.

At first glance it would appear that the PP receives more totes than it ships out. In a physical sense this is true but when the number of parts per tote are taken into account the two balance out. This is due to the assumption that incomming totes contain on the order of 8 to 10 parts while outgoing totes containe between 12 to 20 parts. This equates to a throughput capacity of approximately 280-300 parts per hour, input and output.

TABLE 5
B239 Parts Pool Throughput Capacity

ITEMS	DESCRIPTION	UNITS	GTE	STARTERS	TOTALS
A	Yearly Production	i/y	1600	6000	
B	Average no. parts/item	p/i	150	50	
C	No. work days per year	d/y	240	240	
D	No. work hours per day	h/d	8	8	
E	Avg. no. parts/tote (IN)	p/t	8	10	
F	Avg. no. baskets/item (OUT)	b/i	12	2	
G	INPUT - totes input per hr into the parts pool	t/h	16	16	32
H	OUTPUT - baskets output per hr from parts pool	b/h	10	7	17

Legend:

i = item p = part b = basket t = tote
y = year d = day h = hour

Formulas:

Input: $G = \{[(A / C) \times B] / D\} / E$

Output: $H = [(A / C) \times F] / D$

2.3.1.3 Future Parts Pool Location

A proposed plan calls for the relocation of the existing PP operation into an area of the shop that is more centrally located within B329. The projected move date is set for March, 1987 (see Appendix E for references). Figure 8 illustrates the future area which is contained in the dashed line. Since this area is irregular in shape and contains 35% less floor space than the existing PP area, the project team concentrated on evaluating the feasibility of utilizing high density, mechanized material storage equipment.

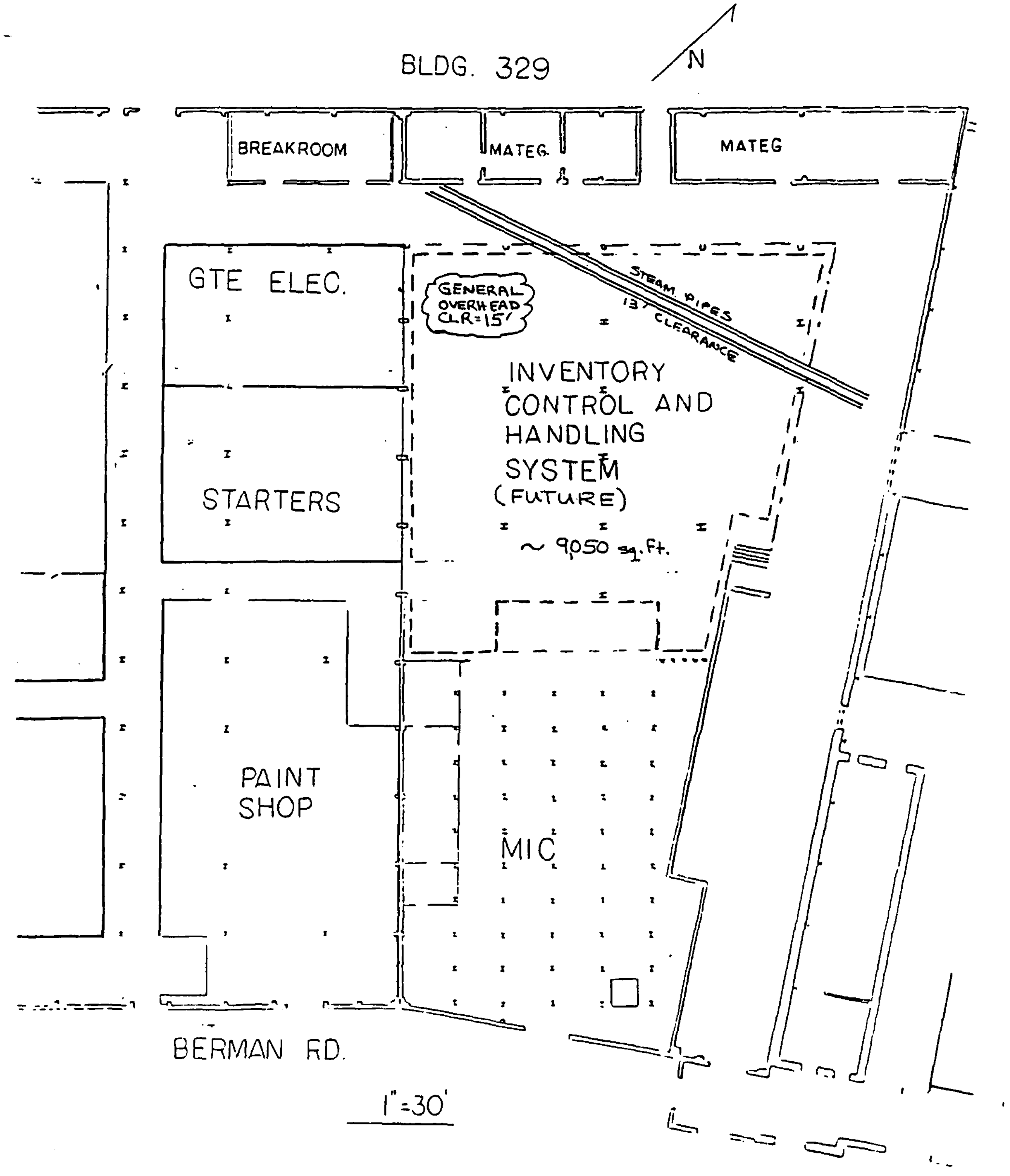


FIGURE 8. Parts Pool Area - Future

Two factors pertaining to the new area initially concerned the team; 1) the irregular shape of the area, and 2) the overhead routing of steam pipes which reduced the ceiling clearance to 13 feet under the pipes. Both features of this area contributed to reducing the effective unit storage cube available for material storage equipment. With these constraints in mind the following material storage methods were considered:

o High Density Shelving - The use of HD shelving proved to be impractical due to the irregular shape of the area which tended to restrict storage space. This form of material storage would have resulted in a very crowded floor, narrow aisles and effectively no area for future expansion or contingency planning.

o Mezzanine Storage - An optional configuration for the HD shelving system would be the addition of a mezzanine floor directly above the main floor. This approach was not feasibile due to the ceiling height constraints of the new area and the need for frequent tote movement between floors.

o Mini-Load Automated Storage/Retrieval System (AS/RS) - Although a viable alternative, the mini-load system posed certain constraints to the response times of tote storage/retrieval as well as restricting access to totes in the event of a mechanical failure or power outage. Other factors included the complexity of the installation, lack of flexibility in relocating the equipment into another area and the costs associated with an AS/RS system for this area.

o Vertical Carousels - The feasibility of using vertical carousels as the main method of part storage was questioned for the following reasons;

  - The chances of interference or collision of odd shape or oversize parts is increased due to the enclosure of the equipment.

  - Access and visibility of totes is more difficult in event of mechanical failure or power outage

  - The ceiling height limitations of the area forces the specification of vertical carousel heights that are not condusive to their application. Carousel height between 18-20 feet would be result in a more efficient application.

  - The cost per unit cube of storage is higher with vertical carousels as compared to horizontal carousel equipment.

However, the team did recommend that vertical carousels be considered for small parts storage as is the case in the starter kitting/de-kitting area which is located in the lower right hand corner of the existing PP area as shown in Figure 6.

- o Horizontal Carousels - The best overall candidate for parts storage rested with the horizontal carousel method of storage. Horizontal carousels offered many features that the team believed were well suited for the new area. These include;

    - High density storage with good space utilization
    - Flexibility with storage bin configurations
    - Ease of maintenance and good access to drive motors
    - More easily handles odd or oversize parts
    - Ceiling clearance allows for efficient carousel heights
    - Allows access to parts in event of power outage or failure
    - Relocation of carousels to other areas is relatively easy
    - Modular construction eases installation

2.3.1.4 Suggested Parts Pool Layouts

Appendix F contains the seven layout drawings which are designated as drawing numbers SK-8917-001 thru SK-8917-007. The words "PROPOSED" and "POTENTIAL" should be kept in mind when referencing these drawings. This is due to the fact that a rigorous analysis has not been performed to substantiate the designs and determine the effects on material flow, facility constraints and labor requirements.

While a detailed layout design is beyond the scope of this study, the seven layouts represent preliminary ideas on how the floor space and available storage volume could be utilized with various storage equipment configurations.

The initial analysis of the proposed parts pool area yielded four potential material storage layouts SK-8917-001 thru 004. These layouts were included in the interim report and were evaluated during a review meeting that was conducted on January 23, 1986. This meeting resulted in the further definition of the future PP layouts requirements and subsequently the generation of layout numbers SK-8917-005 thru 007.

This latter set of drawings (numbers 005 - 007) are all similar in terms of the numbers and types of storage equipment that are used (i.e., 12 ea horizontal and 2 ea vertical carousels), but differ in the way that the equipment is integrated into the PP layout based upon the following list of requirements that were compiled during the review meeting.

- o Main Storage - 12 ea/12 ft, 60 bin horizontal carousels combined with 2 ea/13 ft, 24 shelf vertical carousels. This configuration of storage equipment allows for approximately 43% more storage capacity than the existing PP area which will provide for future workload additions or production increases.

- Computer Control Room - An enclosed control room with room dimension of at least 15 X 10 dimensions should be located in the future PP area to provide environmental control for all computer and peripheral equipment.

- Restricted Storage Area - An area should be reserved for the storage and handling of condemned parts and parts awaiting planner assistance. The team recommends that access to this area be limited to outside the PP only to preclude the chance of mixing good parts with parts whose status is questionable.

- Carousel Kit Storage Capacity - While the main items stored in the horizontal carousels will consist of parts, the carousel storage equipment should have the capacity to store enough kits to support production for one. The majority of the items stored in the carousels will be parts and not kits, but some residual kit storage should be allowed for surge situations. Kit storage capacity will range from 120-140 totes.

- Train Service Drop-off - Entry of totes into the future PP area should be accessible by the B329 train service that runs through the main aisle of the building. The receiving area of the PP should have the capacity to handle a surge of 40 -60 totes.

The primary means of tote handling within the future PP area will be conducted using conventional roller conveyors. This method of material handling provides both a simple and cost effective form of handling and routing totes. It may be advantageous to use power roller conveyors or transporter systems in certain sections of the route due to the length of the movement, restricted aisle widths or the need for tote diverting to carousel work stations.

2.3.1.5 Storage Equipment Specifications

Two types of storage equipment have been used in each of the layouts to provide for tote storage; these include horizontal and vertical carousel systems. The initial recommendations listed below consist of generic equipment specifications that appear to possess the type of attributes that would promote high density storage capacity, ease of maintenance and good operator interface.

- Horizontal Carousels:

Height	= 12 ft	10 ft
Number of bins (B)	= 60	50
Number totes/bin	= 12	10
Bin dimensions	= 21"W x 22"D x 144"H	21"W x 22"D x 120"H
Bin volume (V)	= 38.5 cu.ft.	32.08 cu.ft.
Storage volume (BxV)	= 2,310 cu.ft.	1,604 cu.ft.

o Vertical Carousels:

Height	= 13 ft	15 ft
Number of shelves(S)	= 24	28
Shelf dimensions	= 89-1/4"W x 15-1/4"D x 10-1/8"H (same for both)	
Shelf volume (V)	= 7.97 cu.ft.	7.97 cu.ft.
Storage volume (SxV)	= 191 cu.ft.	223 cu.ft

It is anticipated that the procurement of the new mechanized storage equipment will include new storage tote containers for use exclusively in the parts pool area. The existing tote boxes will not fit the standard carousel bins and using them would require special oversized non-standard bins. Each bin of the proposed horizontal carousels will have a capacity for 10 or 12 shelves or totes (depending on carousel height), while the vertical carousels will consist of smaller bins that will vary in size to accommodate the numerous piece parts that will be stored in it.

Suggested tote sizes have been included to allow for a comparative analysis of storage utilization of the existing storage system with the proposed storage layouts. Actual tote sizes cannot be specified until part sizes, storage quantities and kit contents are analyzed for each part/kit.

Each tote has associated with it an internal and external volume. The external volume is the gross volume required to store the tote in the storage equipment. The internal volume is the net volume available for part storage.

o Tote Containers:

- Existing Totes

  + External volume of 4.4 cu.ft. with dimensions of 27"L x 27"W x 10-1/2"H.

    Vt(e)e = 4.4 cu.ft./tote

  + Internal volume of 3 cu. ft. with dimensions of 22-1/2"L x 22-1/2"W x 10-1/4"H.

    Vt(i)e = 3.0 cu.ft./tote

- New Totes for Horizontal Carousels

  + External volume of 2.7 cu.ft. with dimensions of 23-3/4"L x 19-3/4"W x 10-1/4"H.

    Vt(e)h = 2.80 cu.ft./tote

  + Internal volume of 2.55 cu.ft. with dimensions of 22-1/8"L x 18-1/8"W x 10"H.

    Vt(i)h = 2.30 cu.ft./tote

- New Totes for Vertical Carousels

    + The vertical carousels have an effective storage volume of 7.97 cu.ft./shelf. The size and shapes of the small pa:ts to be stored therein will allow almost complete utilization of the available space.

    + Gross external volume of 7.97 cu.ft./shelf with dimensions that will vary depending upon the parts being stored.

      Vt(e)v = 7.97 cu.ft./shelf

    + Net internal volume of 7.57 cu.ft./shelf which will be on the average approximately 5% smaller than the external tote volume available due to the wall thicknesses of the totes used.

      Vt(i)v = 7.57 cu.ft./shelf

2.3.1.6 Volumetric Analysis of PP Layouts

A volumetric analysis was conducted to compare each of the proposed layouts to the present PP layout. To facilitate this analysis the storage density and cubic space utilization associated with each layout had to be quantified. A gross analysis of the present and future PP locations indicates that major differences exist between the two areas. Table 6 summarizes the differences in attributes between the two locations.

The project team had four concerns pertaining to the future parts pool location:

o Overhead steam pipes - These pipes effectively cut off two feet of ceiling height over 9% of the floor area. It appears that the pipes will not have the impact on storage capacity that the team anticipated if horizontal carousels are used.

o Building posts - The future PP location contains eleven posts within the core section of the room. This compares with only two posts for the existing area. Our concern was that the posts would hinder and restrict the installation of mechanized storage equipment. The use of horizontal carousels will allow the carousel equipment to be installed around these post thus minimizing the effect of the posts on parts storage.

TABLE 6
Parts Pool Room Attribute Comparisons

ATTRIBUTE	PRESENT ROOM	FUTURE ROOM
Location	Adjacent to the E/I shop	Centrally located to all shops in the building.
Posts	2	11
Obstructions	None	Large steam pipes
Access	Good access from two sides of the room, other two sides blocked by walls.	Good access from only one side of the room. A sloping ramp and a 4 ft. wall impair two walls. Last wall blocked by the fence for the MIC.
Ceiling Height	15 ft. over 100% area	15 ft. over 91% area 13 ft. over 9% area (due to pipes)
Shape	Rectangular	Trapezoidal
Dimensions	153' 36.5' 89' less 20'	114' 91' 96' pipes 85'
Area	Ap = 13,617 - 730 = 12,887 sq.ft.	Af = 7,735 + 1315 = 9,050 sq.ft.
Volume (room)	Vp = 12,887 x 15' = 193,305 cu. ft.	Vf = 8,266 x 15' + 784 x 13' = 134,182 cu.ft.
Totes Stored	GTE = 2,200 Starter = 3,050 ------- Total 5,250 totes	Dependent upon layout but not less than; Minimum 8,600 totes

- o Irregular shape - The irregular shape does reduce the effective utilization of the room volume and reduces equipment layout options but it remains to be seen what impact this will have on the final design.

- o Room access - Access to the future PP room will be restricted due to a 4 ft. high retaining wall, ramped walk way and perimeter fence for the MIC room. These leave only one side of the room with good access to parts while stored in the equipment.

As previously mentioned, horizontal and vertical carousels were judged to be good candidates for effective material storage in the new PP application. Within each equipment category two sizes were specified;

Horizontal carousels - 12 ft and 10 ft heights

Vertical carousels - 15 ft and 13 ft heights

Table 7 provides a list of equipment selections for each of the layouts. All layouts use, as a minimum, twelve each of the 12 ft. high horizontal carousels. This group of twelve represent the core of the material storage equipment and is responsible for the high volume utilization and storage density that is attained in the layouts.

TABLE 7
Storage Equipment Configuration Chart

Parts Pool Layout Design Options	STORAGE EQUIPMENT			
	Horizontal Carousels		Vertical Carousels	
	10' 50 bin	12' 60 bin	13' 24 shelf	15' 28 shelf
SK-8917-001	-	12	1	-
SK-8917-002	-	12	5	-
SK-8917-003	-	12	9	5
SK-8917-004	4	12	2	-
SK-8917-005	-	12	2	-
SK-8917-006	-	12	2	-
SK-8917-007	-	12	2	-

Table 8 summarizes the data that was generated in performing the volumetric analysis of the various PP layouts. Each column of the table has been assigned a letter to aid in explaining the calculations for columns C,E,G,H,and I. The legend of the table briefly describes each column and notes the formula that was used to generate the information.

As a general conclusion, each proposed layout resulted in increased storage capacity within a reduced room volume, thus volumetric utilization increased. In other words, for every available cubic foot of volume, the proposed layouts used between 84 to 128% more of this volume to store parts as compared to the existing PP area (refer to column I).

Likewise, overall storage density increased proportionally. The proposed layouts allowed 27 to 58% more part storage volume as compared to the existing area (refer to column H). These numbers provide encouraging results acknowledging the fact that the total available room volume of the new PP location is more that 30% smaller than the existing location.

TABLE 8
Layout Volumetric Comparisons

LOC	Room Volume (A) cu.ft.	Bin Volume (B) cu.ft.	Bin Util (C) %	Tote Vol-e (D) cu.ft.	Tote Util-e (E) %	Tote Vol-i (F) cu.ft.	Tote Util-i (G) %	Comparisons Dens (H) %	Comparisons Util (I) %
P	193305	28000	14.5	23100	12.0	15750	8.1	-	-
1	134182	27911	20.8	24383	18.2	20053	14.9	27	84
2	134182	28675	21.4	25147	18.7	20777	15.5	32	91
3	134182	30554	22.8	27026	20.1	22561	16.8	43	107
4	134182	34518	25.7	30629	22.8	24834	18.5	58	128
5	134182	28102	21.0	24574	18.3	20234	15.1	28	86
6	134182	28102	21.0	24574	18.3	20234	15.1	28	86
7	134182	28102	21.0	24574	18.3	20234	15.1	28	86

Legend:

P = Present PP area
Room Volume (A) = Total room volume
Bin Volume (B) = Total storage bin volume
Bin Util (C) = Bin utilization ratio B/A.
Tote Vol-e (D) = Total external tote volume
Tote Util-e (E) = Tote (external) utilization ratio D/A
Tote Vol-i (F) = Total internal tote volume
Tote Util-i (G) = Tote (internal) utilization ratio G/A

Comparisons:

Dens (H) = Density factor. Change in internal tote storage capacity between the present (p) layout and proposed (l) layouts.

$$[(Fl-Fp)/Fp] \times 100$$

Util (I) = Utilization factor. Change in storage cube utilization between the present (p) layout and proposed (l) layout.

$$[(Gl-Gp)/Gp] \times 100$$

At this time it is important to note that the future parts pool room offers enough cubic space capacity to allow for the storage and control of material that is presently located in the existing PP area. Effective utilization of this volume requires the use of mechanized storage equipment in the form of horizontal and vertical carousels.

Until a detailed analysis of inventory activity is performed, it is not wise to assume that all parts stored in the existing PP area need to be located in the future area. Through the use of computerized inventory control, high density storage and accurate part identification procedures it may be possible (and probable) to reduce the amount of inventory stored in the PP.

2.3.1.7 PP Personnel Requirements

The incorporation of computer controlled mechanized storage equipment will alter the personnel requirements of the future PP area compared to the current staffing levels of the personnel that are assigned to the existing PP area. This analysis does not take into account for shop floor parts expedition. Due to the expected throughput rates that are planned (300 parts/hr), the future PP has been classified as a high volume area.

When using horizontal carousels in high volume applications the project team recommends the assignment of one person for every two carousels. This allows personnel to increase throughput efficiency by allowing them to service one carousel while the other carousel is being indexed for the next action. A preliminary analysis of the labor requirements for layouts SK-8917-005 thru 007 indicates the following:

Carousel Operators	
- Horizontal	6
- Vertical	1
Systems Operator	1
Tote Routers	2
Relief Man	1
Total Personnel =	11

In order to support this high volume load and be able to provide good response times, the following items should be considered for use with the horizontal carousels:

- Carousel speed should be increased to 80 ft/min to reduce response time. The standard speed is normally 60 ft/min.
- Carousel bins should be indexed for side angle picking. The will allow personnel to position themselves in an area between two carousels, and thus service the bins with minimal movement (refer to Figure 9).
- Man lifts will be required to allow personnel to pick parts from reaches that are 5 feet or higher. The team recommends the use of a low profile scissor jack lift with a rated capacity of 1000 lbs. An integrated work station incorporating sound human factors and ergonomic methods should be designed to handle a CRT terminal, tote containers and provide dual side access to carousel bins. Figure 9 depicts a conceptual design of such a carousel work station server. Actuation of the lift could be provided by a foot switch or panel switch.

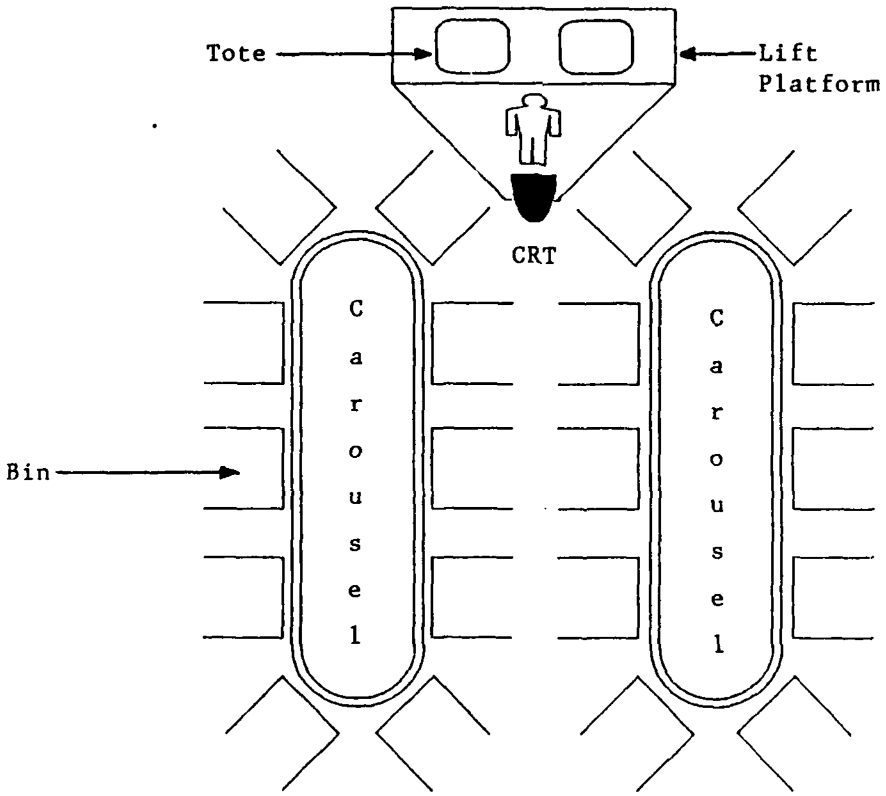


FIGURE 9. Proposed Carousel Work Station Layout

2.4 Material Control System

The accurate tracking of material movements and timely reporting of inventory stock levels are important criterion of all integrated material control systems (MCS). In an automated MCS a central host computer can coordinate the receiving, storing, picking, order filling, order inquiries, inventory checks and shipment scheduling. It can assign storage locations, guide parts into storage and can operate and control automated storage equipment to follow a retrieval sequence to support kit building.

2.4.1 Observations

The preliminary design of an MCS for the B329 operations requires system attributes that address each of the following functions:

- o In-Process Parts Tracking
  - Tagging Methods
  - Data Collection
- o Storage Equipment Control
  - Equipment Interfaces
  - Automatic Indexing
  - Tote Identification
- o Inventory Control
  - Part Identification
  - Tote Locations
  - Stock Levels
  - Order Processing
- o Decision Support Utilities
  - Pipeline Analysis
  - Condemnation Analysis

2.4.1.1 In-Process Parts Tracking

Parts tracking is involved with the identification of parts and the monitoring of part movements through data collection stations. Knowing the type, quantity, location and status of parts that are in-process, allows management to identify potential part shortages or shop bottlenecks. The Maintenance Job Tracking (MJT) system was developed to address these functions of material tracking.

MJT, an AFLC wide sponsored data system designated as G046, was developed under contract by the Ford Aerospace Information Systems division. Using Tandem computer equipment as the system host, MJT was installed in all five ALCs to provide for the tracking of parts within and between facilities.

The system installed at SA-ALC, Kelly AFB includes over 140 CRT/wand terminals dispersed throughout the majority of MA facilities. Table 9 lists the number of barcode wand data collection stations that are located within each building. This data was obtained from Mr. J. Sepulveda/MAWSP directly from an MJT transaction listing.

TABLE 9
MJT Data Collection Stations

Building Number	Number of Stations
301	1
324	20
329	12 *
333	7
348	5
360	15
375	40

* Note: Actual count indicates five (5) MJT terminals located near and/or within the existing parts pool area.

Presently, the utilization of the MJT system is low and for all practical purposes it appears that the system is not being used. In fact, among the five ALCs, Kelly AFB is the only one that has voiced an interest in re-establishing MJT as a tracking system. This statement is made knowing that a request, to authorize Kelly to modify MJT, has been sent to AFLC command from the MAWS systems office. It is not known if MAWS will be granted authority to modify MJT, in light of the development effort that is underway on the DMICS data system (Depot Maintenance Integrated Communications System).

Without getting into the details of DMICS applications, it was clearly understood that the MJT host computer was being quite heavily utilized for development efforts, and that priority for the MJT system was currently set at 5th or 6th down the list and dropping. Since DMICS is not currently available for the MA users, it seems evident that AFLC command has allowed a situation to occur in that the MA user has been left unsupported, without the aid of an effective parts tracking system, and will remain so for another 3 - 5 years until the DMICS system can fill the tracking function.

Acknowledging the fact that the MJT system is a tracking system that is curently available to MA users, a number of conditions exist which have reduced the capacity of MJT to perform the tracking function effectively. Discussions with various MA personnel indicate a range of reasons for its lack of use which include :

- Response Time - Reports of poor response time have been heard from nearly every person interviewed. The team has been informed that response times for interrogation type transactions range from 3 to 20 minutes. Some possible reasons for the poor response times are;

  - System background work that is normally scheduled during off hours sometimes spills over into prime time.

  - The Assignment of very low system priority (5th -6th) forces MJT to contend for CPU resources.

  - Old/inactive job requests or interrogation transactions residing within the system are not cleaned up in a timely manner, thus they tend to choke system throughput and degrade performance.

- Part Identification - Presently, MJT terminal equipment is configured such that barcode scanning wands are attached to CRT terminals. This configuration restricts the working range of barcode wanding and forces shop personnel to move the parts to the terminal as opposed to moving the wand to the parts. Since the wand is attached to the terminal the wand requires that the terminal be inactive in order to log in parts. As will be noted in a latter paragraph, other data systems can be accessed using MJT terminals thus situations ocurr in which the terminal is in use when parts need to be logged in.

  Another part identification problem is associated with the method of attaching WCDs to parts. The present method requires that the WCD be placed in a translucent plastic pouch which is wire tied to the part. This forces shop personnel to remove the WCD, unfold, lay the WCD out flat on a rigid surface and wand the barcode. This procedure burdens personnel with having to perform many manipulations that could be reduced if proper folding procedures were enforced to insure that the WCD barcode symbol could be read thru the pouch.

- Data Integrity - From a user's point of view, the integrity and accuracy of tracking data provides a major portion of the incentive to use a wand and barcode to identify parts and input data. Obviously the saying "garbage in equals garbage out" applies, but in the case of MJT there appear to be three main reasons for loss of data integrity;

  - Part logging is sometimes bypassed if the logging station terminal is being utilized to access other data systems.

- Slow response time from the MJT system to acknowledge part identification impacts the timely routing of parts, thus 'hot' jobs or priority parts may bypass logging if this is the case.

- The quality of some WCD barcodes are so poor that the code must be scanned using numerous passes to obtain a read. This slows the logging process down and places more burden on shop personnel.

o Resource Contention - As noted earlier, the MJT system affords users the ability to access other data systems using MJT terminals that are located throughout MA facilities. Problems arise when an operator is using the terminal to retrieve data from one of these systems while shop personnel are waiting for the terminal to free up so they can log part movements to MJT. The project team believes the use of portable barcode scanners can solve this condition of resource contention. More will be said on the portable units in later paragraphs.

While some of the reasons for MJTs lack of use have been addressed, few have been resolved. Certain MJT files have been rewritten to improve response time and SA-ALC/LM (MJT host computer manager) has acknowledged the need for consistent MJT prioritization, but it does not appear that much of what has been accomplished to date has been able to correct deficiencies and improve system performance and user acceptability.

The project team believes that the MJT system could be used as the main parts tracking system again if the following guidelines were implemented and supported by the systems managers and end users;

o Minimize Tracked Items
o Stabilize System Priority
o Purge Outdated Transactions
o Curtail Interrogation Transactions
o Utilize Portable Data Terminals
o Establish Communications Link with PP Computer System

A survey of the parts tracking requirements for the B329 operation, indicates that approximately 8 - 12 data collection points would be required to provide good coverage of parts movements thru the process. Preliminary suggestions are to locate data collection stations in the following shops:

o Disassembly
o Evaluation/Inspection
o Train Drop Station (back shop routing)
o Paint Shop
o Electrical Shop
o Condemnation Cage
o Parts Pool

The initial tracking station for the GTE/starter parts should be set up just outside E/I as the parts leave E/I and are sent to either the PP, B324 or the condemnation cage. A tracking station could be established in disasembly to acknowledge the induction of whole items. Since missing parts on received items do not ocurr frequently, the disassembly station would be able to provide better visability of pipeline inventories and could be as simple as keying in the model number of the item being disassembled. The information from the disassembly area would be transmitted directly into the PP computer system and would not need to be processed by the MJT system.

In order to "close the loop" on part tracking, it is vital that parts be identified as they arrive into the condemned cage area. This will require that all parts being routed to the cage have a WCD attached so that parts can be identified properly. In addition, data collection stations need to be established in the shipping/receiving portion of the following buildings; B324, B348 and B333. This will, at a minimum, provide tracking information to identify part movements in and out of those buildings.

The tracking process terminates when receipt of parts are acknowledged at the parts pool storage center. The PP system will utilize the MJT barcode symbol on the WCDs to automatically identify parts. This will require the PP computer to have a copy of the MJT database to allow the mapping of the 6 digit code to the items P/N. Realizing that this database, which is resident on MJT, will be constantly changing as parts are tracked, the team recommends that the PP computer requests a current copy of the MJT database on a four hour cycle. The criticality of the tracking data is such that a real time copy would not substaintially enhance the validity of the data residing in the PP system.

The other main source of parts, the MIC, could be automatically identified by reading the barcode symbol that is required to be printed on all packing containers. This code represents the NSN of the item and the PP system will need to map the NSN to the individual P/N. This can be performed by obtaining a copy the database that maps NSN numbers to P/Ns.

Various types of barcode reading/collection equipment can be used to identify and record part movements. Barcode contact wands, hand held laser scanners (HHLS) or, portable Data terminals and in specialized applications, fixed mount laser scanners could be specified. Acknowledging the fact that laser scanning devices are many times more expensive than conventional contact wands, these devices should not be overlooked for their potential impact on reading accuracy and ease of use.

Generally laser scanners offer higher first time reads, wider field of view, high speed automatic scanning (40-200 scans/second) and extended depth of field (8" to 24" standoff) which allows for non-contact reading of symbols thru transparent overwraps on curved or irregular shaped surfaces. Laser scanners will reduce the efforts involved with barcode reading which in turn tends to promote more consistent use of the reading devices by operators.

While discussing the potential use of portable barcode scanners, it was brought to the teams attention that 18 portable data terminals (model MSI/88s) had been purchased for just such a purpose, but to date have not been implemented for use into the MJT system. One of these portable units had been loaned to the team for evaluation purposes. The evaluation concluded that the units feature the necessary attributes required of a portable device, (memory storage, data transmission and reprogrammability), therefore they should be utilized as the principle means of data collection. Benefits derived from the use of portable collection units include;

- Extends the reach of the scanner by allowing shop personnel to bring the wand to the parts.

- Provides instant response times by storing all data into the device memory in which thousands of characters of information could be stored before transferring (uploading) the information to the MJT host computer.

- Encourages the scanning of part documents because the task has been simplified and has removed the burden of part logging, off of the shoulders of the person and onto a computer controlled device.

Of key importance in maintaining a sound part identification system is the use of a common tagging method that includes a consistent tag format and durable media (i.e., laser etched metal tags or paper WCD documents). This aids in providing quality barcode symbols, and helps reduce operator confusion that can occur if multiple part identification tags are attached to parts. The team recommends that the WCD be retained as the main part identification document to be used throughout the building. This should not present a problem since procedures for maintaining WCDs are currently in place to provide for the maintainence and distribution of WCDs.

2.4.1.2 Storage Equipment Control

The host computer for the PP system will be required to control and monitor various devices on the shop floor. This can include the control of carousel interface devices, robotic interface devices, tote weighing system or data collection equipment. It may be helpful to refer to Figure 10 for a pictorial representation of these devices and their location with the proposed system. While all of these devices may not be specified in the final layout, they should be considered for their respective benefits.

- Carousel Interface Devices (CID) - The CID provides an interface between the computer system and the carousel drive motor controller. It is responsible for receiving bin location data from the host computer and controlling the acceleration and velocity of the carousel, resulting in the proper indexing of storage bins. This device is essential for computer controlled automatic carousel indexing and frequently is purchased as part of the system when procuring this type of storage equipment.

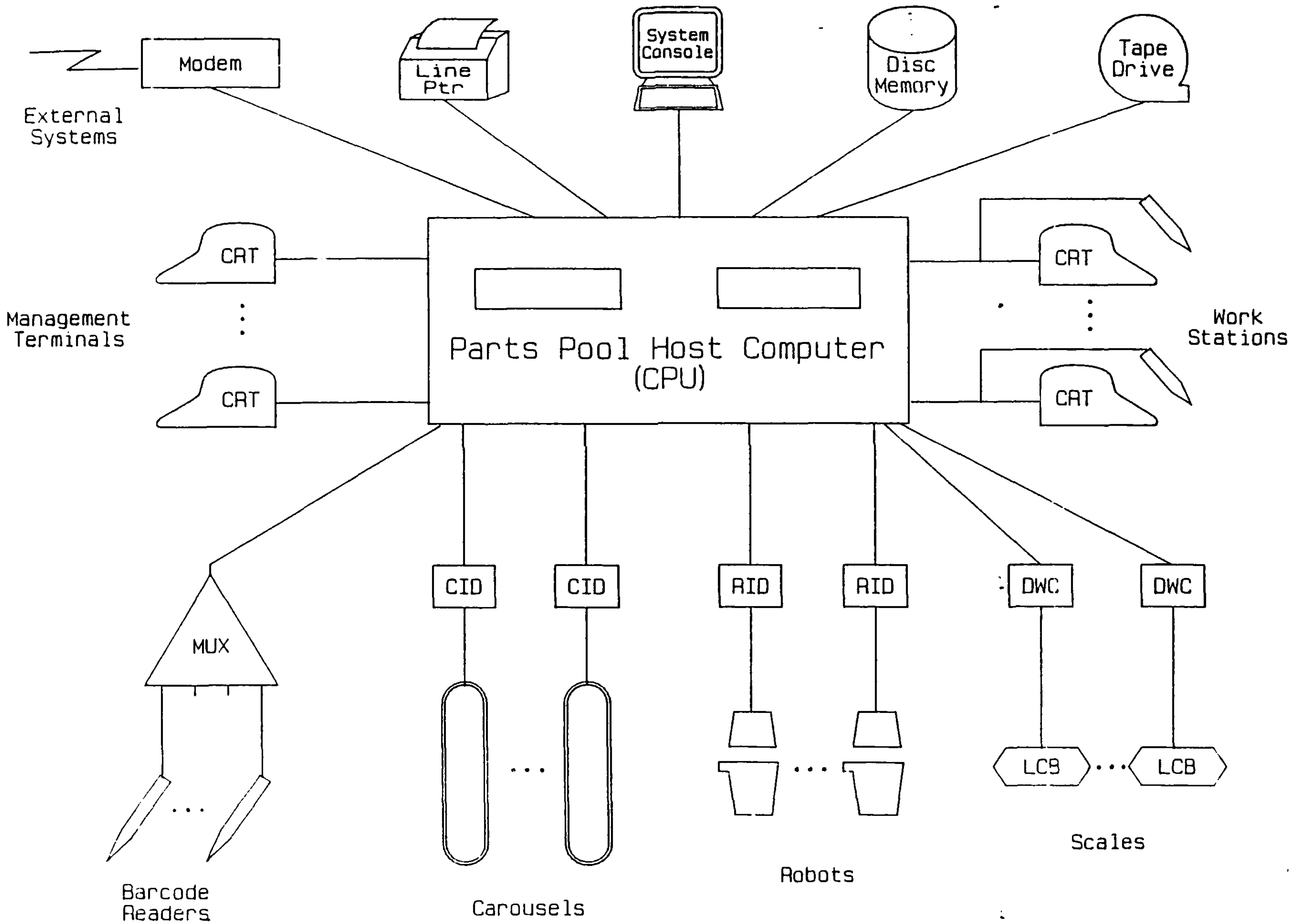


FIGURE 10. Computer System Block Diagram

- Robotic Interface Device (RID) - The RID provides an interface between the computer system and a robotic tote storage/retrieval (S/R) handling unit. A robotic tote S/R machine is used to service multiple carousels by automatically retrieving and storing totes into the bins of the storage equipment.

  Performance of this function requires no manual intervention on the part of PP operators. The RID receives data from the host computer which identifies carousel and bin location numbers. The RID carries out the request by controlling the location of the robot, with respect to carousel location, and adjusting platform height to match the tote height in the bin that is to be retrieved or stored.

  The project team recommends that further analysis be conducted during the design phase (Phase II) in order to make an assessment of the benefits of implementing robotic S/R machines in place of ladder or lift systems. In addition to concerns about increased system cost, the team is concerned that the use of such equipment may increase rather than decrease the system response time to store and retrieve parts from the carousels.

- Tote Weighing System (TWS) - A TWS is being considered to allow for the automatic counting of inventory stored in totes. A TWS is made up of two components, a digital weight converter (DWC) and a load cell base (LCB). The DWC receives a signal from the LCB and converts it into a weight, the results of which can then be displayed or sent to the host computer via RS-232 communication lines. The idea is to integrate the LCB into the platform of the robotic S/R machine or carousel work station server. This would allow the weight of a tote to be measured every time a storage or retrieval operation was performed.

  Two benefits could be realized using a system configuration as described;

  First, the TWS system could provide a check of part quantities within totes which would allow redundant checks of receipts/issues being transacted by operators. It is conceivable that this system could also be used to eliminate monthly manual inventory counts. These functions could be accomplished by storing in the computer database the nominal weight of various classes of totes (i.e., small, medium and large), nominal weight of individual parts and the tote serial numbers assigned to contain specific part numbers. As a tote is retrieved or stored in the carousel, a laser scanner (mounted on the robotic S/R machine) would automatically identify the tote by reading the barcode symbol mounted on the tote. The TWS would weigh the tote and send this data to the computer. The computer would calculate the number of parts within the tote based upon the gross weight that was measured and knowing the individual tote/part weights that would be stored in the database.

Second, since the TWS equipment has a resolution of 1/3 ounce with a capacity of 200 pounds, it is conceivable that this equipment could resolve the commingling or mixing of parts within totes and could raise a 'flag' if inconsistent weights for known tote/part combinations were detected.

2.4.1.3 Inventory Control

An important aspect of the parts pool MCS is the maintenance and control of a real-time (live) inventory database. In other words, as receipt or issue transactions are completed, the inventory database is updated immediately. This real time feature helps to insure data accuracy and consistency and provides management a tool for dynamic scheduling and contingency planning.

The following discussion concentrates on the identification of generic attributes and functions that will be required of the inventory management software for the effective management and control of the parts pool inventory database and storage equipment.

Initially all part specific data and kit contents (i.e., Bill of Materials, BOM) need to be identified and stored in the inventory database. The database will contain data on P/Ns, part descriptions, quantities on hand, location numbers, tote numbers, reorder points/quantities, nominal part weight (optional), kit numbers, kit contents, etc.

In order to perform operations on the inventory, transactions will be selected by operators from a menu of available offerings. Transactions allow parts receipt and issue requests to be executed. A list of some of the more typical transactions includes:

- Issue by P/N - Used to request that a quantity of a part be removed from the inventory from any acceptable location that is assigned to the part.
- Issue by Location - Used to request that a quantity of a part be removed from a specified location.
- Receipt by P/N - Used to request that a quantity of a part be added to the inventory in any acceptable location assigned to the part.
- Receipt by Location - Used to request that a quantity of a part be added to a specified location.
- Inventory Adjustment - Using the system console and entering the appropriate password will allow the database to be modified.
- Inventory Spot Checks - Used to request an inventory check of all locations for a particular part.
- Parts Kitting - Using a BOM listing, all items in a kit will be picked using a single ID code for kit selection.

As transactions are completed and inventory activity is recorded, management will require a host of analysis and status reports which will be used to assess the overall position of the parts pool and its ability to supply parts to meet production requirements. Some of the more important reports include:

- o Performance Statistics - Reports information about carousel and operator performance. Lists active and idle times for each carousel and total time logged on and the number of transactions directed to each operator.

- o Inventory Analysis - Analyzes inventory activity by tracking the material movements of inbound and outbound parts.

- o Kit Analysis - Lists the contents of a kit and calculates the maximum number of kits by end item is that can be built with available inventory on hand.

- o Reorder Point Notification - Searches and reports on those parts whose inventory levels are less than the reorder points that have been established for each respective part.

- o Parts Report - Details part summary information pertaining to quantity stored, committed, and short as well as reorder point and quantity.

- o Locations Report - Used to display information about active locations in the carousel storage system. A storage location is designated by carousel #, bin #, shelf # and cell #.

- o Available Locations - Reports on all empty, unassigned locations by size of the storage location available in the carousel storage system.

2.4.1.4. Decision Support Utilities

Decision support utilities refer to a collection of utilities that allow the user to pose 'What if ' type questions or senarios to the computer system. The computer then processes this request using data that is system resident and displays the results of which are used by the user for decision justification. Decision Support System (DSS) utilities operate with incomplete data many times and thus require the user to define some initial assumptions or values in order for the senario to be executed successfully.

The whole concept of DSS utilities is centered around the ability of taking raw data, processing the data using the constraints and assumptions of the senerios and finally converting the data into information that can be used by the user as the bases of a decision making process.

An example is a situation in which a shop scheduler needs to know if there are enough parts available to support increasing the production requirements by 20 % for a GTE 85-70 series engine. To answer this question the following information would be required;

- o BOM listing for the item model number selected
- o Inventory levels available in the PP
- o Location and quantity of parts in-process inventory
- o Expected flow times for various repair processes
- o Estimated fallout rate from repair processes

Use of the BOM listing will identify the parts required to build the item model specified. Knowing the available inventory levels currently in the parts pool will allow the system to determine if there is sufficient inventory to support the request, if not, then an analysis of the pipeline or in-process inventory will need to be conducted.

If the PP does not contain enough stock to fulfill the requested amounts, then the system will need to identify the location and quantities of parts residing within the in-process inventory. This information will be combined with the knowledge of estimated repair processing flow times and fallout rates to allow the system to make an approximation of when sufficient amounts of in-process inventory could become complete and available.

After the results have been arrived at, the user may choose to re-run the DSS utility but this time he may decide to make adjustments to fallout rates, flow times or production requirements. Once the changes have been identified the DSS utility can be re-run and a comparitive analysis could be conducted to compare the results of the previous run with that of the current to assess system sensitivity.

The definition and development of DSS utilities should be allowed to evolve as the system design activities are further defined during the design phase. This is due to the fact that the ability of a DSS utility to respond and analyze a particular request is dependant upon the data that is available to the system.

2.5 Computer Control System

The design of a computer system to manage the tracking and inventory control of parts, along with the control of material handling and barcode reading equipment will result in a rather complex configuration requiring the need for specialized equipment, software, resources and personnel.

Depending on the requirements of the automated material handling equipment, number of management terminals, data input stations (ie., wands) and external system communication links; the computer system configuration could be simplified or expanded from what is represented in Figure 10. This example configuration represents some of the possible peripherals that the CPU could be required to communicate and control.

2.5.1 Observations

The following paragraphs provide brief explainations of some of the requirements and considerations that will need to be addressed during the design phase of the system:

- Hardware expandability and upward compatibility of hardware and software are main features that must be carefully studied when evaluating a system configuration. Systems that possess good expansion compatibility more easily allow incremental steps of implementation to occur without having to rewrite software or replace the system host CPU.

- Due to the nature of the live inventory data that will be resident on the system, it is recommended that procedures be established and maintained, to ensure that no more than one days worth of data could be lost in the event of a computer system/component failure. A normal procedure which should accomplish this requirement would be routine, daily, incremental backups and complete weekly backups, to an off-line storage media such as magnetic tape. These duties require the attention of a full time system manager that is on site during normal working hours. Provisions should be made to obtain such personnel.

- An equipment maintenance contract should be established, or use of an in-house capability must be provided to ensure that any computer hardware failures are resolved within 24 hours of problem occurrance. This is imperative to maintain a useful system and, most importantly, to avoid confidence degradation within the minds of the users.

- Provisions for maintainence and modification to software should be established with an outside firm or an agreement established in-house with MAW computer analysis. Without doubt, the need for this type of service will become a reality sometime in the future. In order to reduce the time and costs involved with an undertaking of this kind, the applications software should be programmed in a mature, widley supported language (ie. FORTRAN 77 C, PASCAL). Fourth generation languages such as FOCUS should not be overlooked for an application of the type.

- Complete and through documentation will promote timely and effective corrective action if problems occur. Documentation is not only required for the system host and its peripherals (ie. printers, disc/tape drives, terminals, modems, ...), but also a detailed map of all I/O lines eminating from the host to junction boxes out on the shop floor is necessary documentation.

- Numerous environmental factors need to be considered with the host system and the attached peripherals and components. Such factors as operating temperature, relative humidity, particulate filtering, static electricity and power line conditioning will all have an effect on the type of packaging required for each device. Interviews with shop personnel indicate that internal shop temperature extremes range from 10 to 100 degrees F.

- Not-to-be-neglected will be effective training of the staff who will be using and interacting with the system at all levels. Training plans will need to be established for the following types of personnel:

  - Host System Manager
  - Schedulers
  - Expeditors
  - Managers
  - Parts Pool Personnel
  - Shop Floor Personnel

- A critical and often underestimated system parameter is response time. Nothing discourages user more than an unresponsive computer system. Efforts need to be directed at quantifying acceptable response times for the following type of requests:

  - Management terminal requests
  - Part identification acknowledgement
  - Material storage/retrieval times

3.0 CONCLUSIONS

The following list of conclusions represent the product of analyzing the observations and information that were collected from personnel interviews, document abstraction or direct observations that ocurred during the contract reporting period. The majority of the conclusions focus upon the existing procedures being used to move, identify and process parts throughout the overhaul process within B329.

- The existence of large in-process buffers are restricting the flow of parts thru the cleaning and E/I shops. The size of the buffers are directly affected by two factors; 1) the capacity of individual shops and 2) the policy of increasing end item input to generate critical parts.

- The stacking of totes one on top of each other makes it very difficult to identify specific parts. This reduces the effectiveness of job prioritization and results in some parts residing in the buffer for lengthy periods of time.

- The timely and accurate accounting of condemned parts is vital to precluding parts shortages. All condemned parts should be handled expeditiously to initiate, at the earliest possible time, the procurement of a replacement part from the MIC. The recent establishment of a condemnation point in the disassembly shop is a positive move toward addressing this problem.

- The accurate estimation of part repair flow times is a primary factor governing the effectiveness of production schedules. Flow time estimates are dependent upon job prioritization and backlog within the shops outside of B329. Current flow times within the repair process vary widely from what it realistically should take.

- Attaching paperwork (metal tags, WCDs, routing slips, etc.) to parts using wire does not provide a positive means of part attachment. Parts with missing documents presents problems to the overhaul process by having to re-inspect or re-handle these parts. The use of single stranded copper wire to attach the tag or pouch to the part seems to be vulnerable to improper application and to frequent handling.

- The proliferation of coded or tagged documents that are being attached to parts (i.e., metal tags, WCD, laser tags) may present a problem to shop personnel in identifying the propoer tag or document to wand. It does not appear that any efforts are being implemented to reduce the number and types of documents that are attached to parts for tracking purposes.

- Frequently the folding and placement of WCDs in the plastic pouches is performed in such a way that the part information cannot be read without removing the WCD. If the MJT system (or any tracking system reading the WCD barcode symbol) was being used, it would require a considerable amount of time to remove, unfold, wand the barcode, re-fold and insert the WCD back into its pouch. Care should be taken to fold the WCD in such a way as to make the barcode symbol visible through the pouch.

- Adherence to WCD color coding is important for gross part identification. A couple of cases were observed in which a WCD for a GTE engine was printed on white paper when it should have been on printed on green paper.

- The quality of the barcode symbol on the WCD documents do not appear to be of high enough quality to be conducive for first time reads (single pass interpretation) using a conventional barcode wand. A majority of the symbols observed suffered from printing voids and specks. Poor printing quality not only results in non-reads but can lead to more serious problems such as character substitution errors or mis-reads.

- The future parts pool location can be used to accomdate the storage, handling and control of parts for B329. Two attributes exists of the room act to constrain and reduce the layout options. These include the ceiling clearance under the overhead pipes that run diagonally across the northest portion of the room, and the irregular shape of the room with restrictions to asile ways due to varying elevations around the perimeter of the room.

4.0 RECOMMENDATIONS

Based on the observations and conclusions that were reached during the contract period, the project team offers the following recommendations;

- o Horizontal carousels should be utilized in the future parts pool location for material storage. Generic specifications for the carousels are 12 ft high, 60 bin, bottom drive carousels with a CID control device to allow the equipment to be placed under the control of a mini computer which will automatically accelerate, decelerate and index the carousel equipment.

- o Commerically available tote containers should be procured for use solely in the carousels. The following tote specifications are recommended; minimum of 2.2 cu. ft. internal volume capacity, reinforced rib construction with divider notches and registration points for use with automated handling tote extraction equipment. The totes should be confined to the PP area only and not allowed to co-mingle with the normal shop totes.

- o Vertical carousels should be utilized for small item storage. The generic specifications are; 13 ft high, 24 bin carousels with a CID control interface. A small standard size tote that provides approximately 1/2 cu. ft. of internal volume capacity should be used for internal segregation.

- o The interface between PP personnel and the mechanized storage equipment will ultimately determine the efficiency and effectiveness of the PP systems operation. To address this interface, the team strongly recommends that during the design phase (Phase II) of the PP system, a task be established to provide for the thorough design of the carousel work station/lift (WSL) equipment (refer to Figure 9 for a conceptual drawing).

  The WSL should integrate the following functions;

  - Vertical lift capabilities will be required to allow shop personnel to safely reach the top shelves of the carousels. This lift should provide for a vertical displacement of 7 ft and have a capacity of 1000 lbs. A low profile scissor jack lift mechanism would be well suited for this application and should be actuated either using a foot switch or control panel mounted switch.

  - A CRT display will provide prompts to allow the operator to obtain storage or picking instructions while on station. The work station should be able to accomodate two totes that are within easy reach of the operator, and should allow the operator access to either carousel at all times.

- A general purpose mini-computer system will be required to provide the following functions in the Parts Pool center; storage equipment control, inventory database maintenance, data logging from barcode/CRT terminal points, communications with the MJT host computer and DSS utilities for analysis. The computer hardware should consist of a mini-computer with a minimum of 1 MB of memory, a system clock, a hard disk drive with 200-400 MB storage capacity, a removable disk for data portability, a systems console CRT, a magnetic tape drive for database backups, a high speed line printer for report generation and various I/O cards to support data communications.

- The establishment of a restricted storage area, for the holding of condemned, scrapped or parts requiring planner assistance, at the northeast corner of the future PP area should only be accessible from outside the main PP area. The team strongly recommends that this restricted storage area be carefully controlled in order to preclude the opportunity of mixing scrapped or condemned parts with good inventory.

- All parts being received in the PP area should have appropriate identifying documents (i.e. WCDs) attached to the part. This will reduce the opportunity for mis-identification and process completion. The policy of inserting a stack of WCDs in the tote with the parts concerns the team because this puts the burden of attaching the documents to the parts on the PP personnel.

- Control of the parts within the PP area is essential in maintaining inventory accuracy and reducing material pilfering. Although a fence is used to provide perimeter control of the existing area, the gates to the fence are not controlled. The new PP location should have security and control in mind when the area layout is designed.

- The tracking of parts within B329 and to/from other outside shops should be accomplished using the existing MJT tracking system. As noted in the report, there are many areas of the system operation that need to be addressed and procedures established. In order to return the MJT to an effective tracking system the following guidelines must be followed;

  - the number of parts that the system tracks should be reduced to critical items only

  - a stable and moderately high priority should be established and maintained

  - general system housekeeping should be performed periodically to purge outdated transactions

  - a communications link must be established between the MJT system and the PP mini-computer to allow for file transfers

- all data collection work stations should be equipped with portable data terminals with barcode wands.

- o Tracking of parts should initially be limited to selected points within B329 and selected outside shops. The team recommends the establishment of data collection points at the following locations within B329;

  - Disassembly
  - Evaluation/Inspection
  - Train Drop Station
  - Electrical Shop
  - Condemnation Cage
  - Parts Pool (in/out)

  Additionally, data collection points should be established within the shipping/receiving portions of the following buildings; B324, B348 and B333.

The validity of the recommendations listed in this report are based upon the information that was gathered during the course of the study. The true substantiation of these recommendations can only be accomplished under a complete and thorough design phase. Without question, during the design phase as more complete detailed information is acquired, system attributes and equipment specifications will be more rigorously analyzed and evaluated.

The original proposal that was prepared by SwRI to address the B329 facility, (SwRI proposal no. 14-3136, dated May 15, 1985) , proposed that the program be conducted in three phases. The phases included;

- o PHASE I - Definition and Planning
- o PHASE II - Design
- o PHASE III - Implementation

A phased approach to program development was proposed, and is still strongly supported, to ensure that MAT management maintained specific control over the direction/progress of the program as well as all budgetary considerations.

Pending the validation by MAT personnel, of the findings from Phase I, the next step toward program development is to issue Phase II to initiate the system design efforts. SwRI remains confident that the parts tracking and material storage systems can be designed to provide an effective integrated material control system for the B329 overhaul process. The recommendation is that the design phase be pursued utilizing the findings and conclusions derived from this study.

APPENDIXES

A. Project Contact Sheet

B. Initial Survey Checklist

C. Documents Received

D. Work Control Documents

E. Bldg 329 Systems Implementation Plan

F. Parts Pool Layout Drawings

Appendix A

Project Contact Sheet

Contract No. F41608-86-C-A016 SwRI Project No. 14-8917

NAME	PHONE	SYMBOL	BLDG	OFFICE	K	I
(SwRI)						
ROY THOMPSON	522-3757	D-14	SwRI	PROGRAM MANAGER	X	
TOM DER TATEVASION	522-3763	D-14	SwRI	PROJECT MANAGER	X	
LARRY POIRIER	522-2430	D-06	SwRI	MATERIAL STORAGE	X	
DAVID VICKERS	522-3087	D-14	SwRI	COMPUTER SYSTEM		
ALEX GARZA	522-2238	D-72	SwRI	CONTRACTING		
(KELLY AFB)						
SAM DER TATEVASION	925-8441	MATS	B308	SCHEDULING BRANCH	X	X
PETE CUBELLIS	925-8441	MATSM	B308	SCHEDULING SYSTEMS	X	X
VINCENT CHACON	925-8441	MATSM	B308	SCHEDULING SYSTEMS	X	X
BOB KLIER	925-6411	MATSE	B239	STARTERS SCHEDULING	X	X
RITA KELLER	925-3943	MATSG	B329	GTE SCHEDULING		X
CAPT. GREEN	925-3943	MATSE	B329	GTE SCHEDULING		X
OLIN CLAYBORNE	925-6447	MATEG	B329	GTE ENGINEERING	X	
TOM GREEN	925-8831	MATEG	B329	GTE ENGINEERING	X	
MIKE GOOS	925-8831	MATEG	B329	GTE ENGINEERING	X	X
ART GARZA	925-8937	MATSN	B324	MACH SHOP SCHEDULING		X
KEVIN SCHNITZER	925-4323	MATEA	B324			X
MANUAL DIAGO	925-4323	MATEA	B324	MSAPIS OPR		X
RICHARD RODRIGUEZ	925-7261	MATSEG	B329	GTE PARTS POOL		X
JOE PEREZ	925-6411	MATSEG	B329	STARTERS PARTS POOL		X
JOE SEPULVEDA	925-6201	MAWSP	B324	MJT OPR		X
CHARLES BUCKHOLDT	925-8711	MATEF	B308	ENGINEERING		X
LARRY OCHS	925-7491	MAWF	B324	MA PROJECTS OFFICE		
DEAN PACE	925-4854	PMWAF	B43	CONTRACTING		
MOSES ESCOBEDO	925-8885	MATEA	B324	WCD CONTROL OFFICE		X
JUAN JUAREZ	925-6201	MAWSPE	B324	PLANNING SYSTEMS UNIT		X
THOMAS ACOSTO	925-6201	MAWSPE	B324	PLANNING SYSTEMS UNIT		X
JAMES TREVINO	925-8558	MAWS	B324	INDUSTRIAL SYS BRAND		X

LEGEND:

K = KICK-OFF MEETING

I = INTERVIEWED

Appendix B

Initial Survey Checklist

SOUTHWEST RESEARCH INSTITUTE

GTE/STARTER REPAIR SHOP INITIAL SURVEY CHECKLIST

PROJECT NO: 14-8917

CONTRACT NO: F41608-86-C-A016 DATE: 18 NOV 85

A: INDUCTION (Receiving Items for Repair)

1. Verify shipping documents? ✓ YES ____NO
2. Sign for item(s)? ✓ YES ____NO
3. Log items in? ✓ YES ____NO
   If so, how? 1. AFLC FORM 20 2. SCHEDULER 3. ENTERS RECEIPT OF ITEM(S) IN G00 4L SYSTEM W/ R/A TRANSACTION CARD.
4. Any forms initiated at this point? ✓ YES ____NO
   If so, what forms? R/A TRANSACTION CARD. ACKNOWLEDGE RECEIPT TO D033 (SUPPLY INVENTORY SYSTEM) AND LOG INTO G00 4L SYSTEM.
5. Items unpacked & containerized? ✓ YES ____NO
6. Items marked or tagged at this point? ____YES ✓ NO
   If so, what with? 5. STARTERS ON PALLET, GTE'S ON CARTS NO ADDITIONAL MARKING OR TAGGING AT THIS POINT
7. Items checked for missing components/parts? ____YES ✓ NO
   If so, what documentation? N/A MISSING OR OBVIOUS PHYSICAL DAMAGE REPORTED AT DISASSEMBLY.
8. Buffer storage before moving to Disassembly? ✓ YES ____NO
   If so, where? STARTERS: IN HALLWAY ON PALLETS GTE'S HAVE FENCED STORAGE LOT JUST OUTSIDE BLDG 329
9. Items logged out & moved to Disassembly? ____YES ✓ NO
   How? By whom? N/A NO DOCUMENTATION OF MOVEMENT BETWEEN RECEPTION AND DISASSEMBLY.
10. Any other action on reception ? ✓ YES ____NO
    If so, List in Remarks.

Remarks: GTE: DISASSEMBLY FOREMAN KEEPS TRACK OF AND MAKES DAILY REPORT OF NO. OF ITEMS DISASSEMBLED TO SCHEDULING

SOUTHWEST RESEARCH INSTITUTE

GTE/STARTER REPAIR SHOP INITIAL SURVEY CHECKLIST

PROJECT NO: 14-8917

CONTRACT NO: F41608-86-C-A016 DATE: 18 NOV 85

B. DISASSEMBLY

1. Any Transfer Documentation? ____YES __✓__NO
2. Sign for item(s)? ____YES __✓__NO
3. Log items in? ____YES __✓__NO
   If so, how? N/A
   NO TRANSFER DOCUMENTATION
4. Any forms initiated at this point? __✓__YES ____NO
   If so, what forms? WCD FOR BOLT-ON SUB-ASSEMBLY REPAIR; ROUTING LIST FOR ~~SUB~~ ELECTRICAL HARNESSES
5. Buffer storage before disassembly? ____YES __✓__NO
   If so, Where? NONE OTHER THAN AS LISTED ON PAGE 1 A. 8
6. Disassembly Level
   Complete? __✓__YES ____NO
   Sub-assembly? __✓__YES ____NO
7. Are any sub-assemblies/parts sent out to any other shop? (Hydraulic, etc.) __✓__YES ____NO
   If so, What? Where? ELEC. SHOP, + MANY OTHERS IN ACCORDANCE WITH APPLICABLE PICTURE BOOK
8. Parts Marked or Tagged at this point? __✓__YES ____NO
   If so, what with? METAL TAGS FOR ALL ITEMS TO BE CLEANED, WCD FOR BOLT-ON'S.
9. Parts sorted, segregated, containerized? __✓__YES ____NO
   If so, How? ACCORDING TO METAL (ALUMINUM, MAGNESIUM, ETC) IN STEEL WIRE BASKETS FOR BLDG 360 ITEMS OTHERS IN TOTE BOXES (TUBING, WIRING, ETC)
10. Buffer storage for Parts? __✓__YES ____NO
    Where? Containers? ON FLOOR, IN TOTES AND WIRE BASKETS
11. Parts Logged out for internal cleaning? ____YES __✓__NO
12. Parts Logged out for Bldg 360 (Cleaning)? ____YES __✓__NO
13. Missing parts logged out? ____YES __✓__NO
14. Fallout (Condemned) parts logged out? N/A ____YES __✓__NO
15. Any other action on Disassembly? __✓__YES ____NO
    If so, List in Remarks.

Remarks: 14. SHOULD PREPARE A REQUISITION FOR REPLACEMENT OF MISSING PARTS, OR PARTS WITH OBVIOUS PHYSICAL DAMAGE. THIS IS TO BE IMPLEMENTED SOON!

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GTE/STARTER REPAIR SHOP INITIAL SURVEY CHECKLIST

PROJECT NO: 14-8917

CONTRACT NO: F41608-86-C-A016

DATE: 18 NOV 85

C. CLEANING (Bldg 329)

1. Any transfer documentation? ____YES __✓__NO
2. Sign for parts? ____YES __✓__NO
3. Log parts in? ____YES __✓__NO
   If so, how? N/A

4. Any forms initiated at this point? ____YES __✓__NO
   If so, what forms? ________

5. Buffer storage before cleaning? __✓__YES ____NO
   If so, Where?
   ON FLOOR, IN TOTES (≈ 400 TOTE BOXES)

6. Parts Cleaning method?
   BUFFING, GLASS BEAD, CHEMICAL DIPPING

7. Parts marked or tagged at this point? ____YES __✓__NO
   If so, what with? ________

8. Parts logged out of cleaning? ____YES __✓__NO
9. Buffer storage for inspection? __✓__YES ____NO
   How? By whom? Where? ON FLOOR, IN TOTE BOXES
   (≈ 600 TOTE BOXES)

10. Any other action on Cleaning? __✓__YES ____NO
   If so, List in Remarks.

REMARKS: 90 % OF ITEMS ROUTED TO BLDG 360 ARE SENT THROUGH BLDG 329 CLEANING FOR FURTHER ACTION, SUCH AS BUFFING, GLASS BEAD BLASTING, ETC.

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GTE/STARTER REPAIR SHOP INITIAL SURVEY CHECKLIST

PROJECT NO: 14-8917

CONTRACT NO: F41608-86-C-A016 DATE: 19 NOV 85

D. CLEANING (Bldg 360)

1. Any transfer documentation? ____YES _✓_NO
2. Sign for Parts? ____YES _✓_NO
3. Log Parts in? ____YES _✓_NO
   If so, how? N/A

4. Any forms initiated at this point? ____YES _✓_NO
   If so, what forms?

5. Buffer storage before cleaning? ____YES _✓_NO
   If so, Where?

6. Cleaning method?
   DIPPING, DEGREASING

7. Parts marked or tagged at this point? ____YES _✓_NO
   If so, what with?

8. Parts logged out for return to Bldg 329? ____YES _✓_NO
9. Parts logged back in at Bldg 329? ____YES _✓_NO
   How? By whom? To where?

10. Any other action on Cleaning? ____YES _✓_NO
    If so, List in Remarks.

Remarks:

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GTE/STARTER REPAIR SHOP INITIAL SURVEY CHECKLIST

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E. INSPECTION & EVALUATION

1. Any transfer documentation? ____YES __✓__NO
2. Sign for Parts? ____YES __✓__NO
3. Log Parts in? ____YES __✓__NO
   If so, how? N/A

4. Any forms initiated at this point? __✓__YES ____NO
   If so, what forms? AFLC FORM 959 or 958
   WORK CONTROL DOCUMENT (WCD)

5. Buffer storage before Inspection? __✓__YES ____NO
   If so, Where? ON FLOOR, IN CRATES, PLUS ON CONVEYERS
   INSIDE INSPECTION

6. Parts Inspec. keeping up w/process? ____YES __✓__NO
7. Parts marked or tagged at this point? __✓__YES ____NO
8. Parts segregated: Accept, Reject, Repair? __✓__YES ____NO
   If so, what with? WITH WCD MARKED SAL, REPAIR
   ETC. NOT SEGREGATED PHYSICALLY AS THEY COME OUT OF
   INSPECTION
9. Parts logged out & moved to repair? ____YES __✓__NO
   How? By whom? NOT LOGGED.
   PICKED UP BY MATERIAL EXPEDITERS SUPPORTING BACK SHOPS.
10. Parts logged out & moved to Parts Pool? ____YES __✓__NO
   How, By Whom? NOT LOGGED
   MOVED TO PARTS POOL BY MATERIAL EXPEDITERS.

11. Rejects logged out & moved to disposal? ____YES __✓__NO
12. Any other action on Inspection? ____YES ____NO
   If so, List in Remarks.

REMARKS: 11. NOT LOGGED. MOVED TO MLC BY MATERIAL EXPEDITERS.

12. MAY BE REINSPECTED DUE TO LOST PAPERWORK, FLOW INTERRUPTION, MISIDENTIFICATION, ETC.

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GTE/STARTER REPAIR SHOP INITIAL SURVEY CHECKLIST

PROJECT NO: 14-8917 — Page 6 of 8

CONTRACT NO: F41608-86-C-A016 — DATE: 12 NOV 85

F. REPAIRS (Bldg 324)

1. Any transfer documentation? ____YES _✓_NO
2. Sign for Parts? ____YES _✓_NO
3. Log Parts in? ____YES _✓_NO
   If so, how? COULD BE TRACKED THROUGH MIT SYSTEM, BUT IT IS NOT BEING USED.
4. Any forms initiated at this point? ____YES _✓_NO
   If so, what forms? ____________
5. Buffer storage before Repairing? _✓_YES ____NO
   If so, Where? BINS IN BLDG 324
6. Parts Repaired keeping up with process? ____YES _✓_NO
7. Parts marked or tagged at this point? ____YES _✓_NO
   If so, what with? COULD BE RED TAGGED
8. Parts logged out for return to Bldg 329? ____YES _✓_NO
9. Repaired parts put back into inspection loop? ____YES _✓_NO
10. Irrepairable or machining error parts logged out and set aside for disposal? ____YES _✓_NO
11. Any other action on Repair? _✓_YES ____NO
    If so, List in Remarks.

Remarks: 10. IRREPAIRABLE/CONDEMNED PARTS RETURNED TO BLDG 329 MIC FOR DISPOSAL.

11. SOME PARTS COULD BE SET ASIDE FOR ENGINEERING ASSISTANCE.

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GTE/STARTER REPAIR SHOP INITIAL SURVEY CHECKLIST

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G. PARTS POOL

		YES	NO
1.	Parts pool a controlled area?		✓
2.	Any Transfer Documentation		
	New Parts (MIC)?		✓
	Inspected parts (SAI)?		✓
	Repaired Parts?		✓
3.	Sign for Parts?		✓
4.	Log Parts in, Add to Inventory?		✓

If so, what system, how? ____

5. Any forms initiated at this point? ✓ YES ___ NO

If so, what forms? RUNNING KIT TALLY

		YES	NO
6.	Parts shelved as received?	✓	
7.	Unique shelving, bins, etc, required?		✓
8.	EOQ (expendable) items stored in Pool?	✓	
9.	Kit definitions readily available?	✓	
10.	Safety stock level established?		✓
11.	Parts pulled for Kits logged out?	✓	
12.	Kits marked or tagged?	✓	

If so, what with?

11. LISTED ON RUNNING KIT TALLY

12. 3X5 MANILLA TAGS, MASKING TAPE

		YES	NO
13	Kit Inventory Level maintained?	✓	
14.	Parts Kits logged to assembly?		✓

How? By whom? To where?

13. STARTERS, YES; GTE'S NO

15. Any other action on Storage/Kitting? ✓ YES ___ NO

If so, List in Remarks.

Remarks: 2. WCD STAYS WITH EACH PART, EVEN IN KITS

6. OVERHAUL KITS FOR PRE-BUILDING INCLUDED IN ASSY [illegible]

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GTE/STARTER REPAIR SHOP INITIAL SURVEY CHECKLIST

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H. CURRENT JOB TRACKING SYSTEM (MJT)

1. Data Entry Wand location points? 4 IN PARTS POOL, BLDG 329. 1 @ KIT OUTPUT; 1 INSIDE GTE SCHEDULING OFFICE; 1 AT GATE BY GTE SCHEDULING OFFICE; 1 AT PARTS POOL INPUT POINT.

2. Terminal Locations? SAME AS ABOVE.

3. Terminal/Wand Users? ORIGINALLY, TRAINED EXPEDITERS. AS OF NOW, NONE.

4. What kind of data is extracted from system? ONCE, LOCATION + QUANTITY BY PART NO. IN A GIVEN SHOP AREA. NOW, NONE.

5. Other information, remarks. N/A

Appendix C

Documents Received

Contract No. F41608-86-C-A016 SwRI Project No. 14-8917

1. Drawing, Parts Pool Layout, Present
2. Drawing, Parts Pool Layout, Proposed
3. Drawing, Building 329 Layout, Past
4. Drawing, Building 329 Layout, Present
5. Drawing, Building 329 Layout, Future
6. Drawing, Building 324 Layout, Present
7. Work Control Documents, numerous
8. Metal Tags, Address-o-graph
9. G046 System Transaction Index
10. MAT Parts Flow Diagrams
11. E-G046-01A (MJT) Study Guide/Workbook
12. GTE/Starter Kit Sheets, SAAMA 430
13. MSI/88s Portable Data Terminal Operators Guide

Appendix D

Work Control Documents

TC126G	WORK CONTROL DOCUMENT (MEDS)	1. DATE 81287	PAGE 4 OF 14 PAGES

2. JOB ORDER NO	3. QUANTITY	4. PRODUCTION SEC/RCC	5. DATE SCHED.	6. DATE COMPLETED
13010A		MTP9E		

7. PART NUMBER	8. TECH DATA	9. ITEM SERIAL NO.
372696	2G-GTC85-13/NAVAIR 03-105 BC-27	

10. MODEL-DESIGN-SERIES	11. STOCK NUMBER	12. OPTIONAL
GTC85-116	2835006265562	2835006265562 DUCT 372696+13010A 13010A *003151*
13. SERIAL NUMBER	14. NOUN	
	DUCT INTERSTAGE	

15. DISPATCH STATION	16. PERF RCC/OP NO	17. WORK TO BE ACCOMPLISHED	18. MECHANIC	19. "P"	20. "Q"
		(8, FIG 4-16) BASKET NO 5			
PS16	010 MTPSI	FLUORESCENT PENETRANT INSPECT IAW PARA 6-18.	N		B
PS16	020 MTPSI	INSPECT IAW PARA 6-100.	M		B
		ROUTE TO STA. B-6, BLDG. 324			
C12	040 MTPNC	REPAIR IAW PARA 6-170. ROUTE TO STA. B-1, BLDG. 301	M		
B-1	045 MEIAA	CORROSION TREAT IAW PARA 6-21	M		
		ROUTE TO STA. B-14, BLDG. 329			
PMM1	050 MTPMM	PAINT SPRAY IAW PARA 6-25.	M		B
		ROUTE TO PARTS POOL STA. B-14.			

21. FINAL DESTINATION DISPATCH	FUNCTIONAL CODE	22. COORDINATION/INITIATING RCC SIGNATURE		23. DOCUMENT/SN
B14	MATSM	A MATEP 22 Oct 81 H. E. Hodges	C MATSE M. Castillo 23 Oct 81	TC126G
		B MTPSI James Gardner 23 OCT 1981	D MAQT 23 Oct 81 A. Solis	

AFLC FORM 958 MAY 79 PREVIOUS EDITION WILL BE USED

TA726F * WORK CONTROL DOCUMENT * 1.DATE 84145 PAGE 1 OF 1 PAGES

2.ORIG/PROD NR	3.QUANTITY	4.PROD SECTION/RCC	5.DATE SCHED	6.DATE COMP
13255A		MTPG9E		

7.PART NUMBER	9.ITEM SERIAL NR	8/12.TECH DATA/OPTIONAL
378102-10		2G-GTC85-3 2G-GTC85-33-6
10.MODEL/DESIGN/SERIES	11.STOCK NR	
GTC85-70A	2835008691850	
13.MISC	14.NOUN/END ITEM NOUN	
	SPACER SET (74, FIG. 4-17)	MISTR

15.DISP-16.PDN/ STATION	OP NO.	17.WORK TO BE ACCOMPLISHED	18.MECH	19"P"	20"Q"
		ESK 13 ITEM 20 SAAMA FORM 430			
PSI6	005 MTPSI	MAGNETIC PARTICLE INSPECT IAW WP 005 00	N		
PSI6	010 MTPSI	VISUALLY INSPECT IAW WP 004 00	M		
PSI6	020 MTPSI	INSPECT DIMENSIONALLY IAW WP 004 00	M		
PSI6	030 MTPSI	CORROSION TREAT, OIL DIP IAW T. O. 2-1-11	M		
B14	040 MATSE	PARTS POOL			
		MATEAA Ray Guajardo 13 JUN 1984 MTPSI A. Misquiz JUN 13 1984 MATSE Felipe Fuentes 14/JUN/84 MAQT Ambrose Yanez JUN 15 1984			

TA223G * WORK CONTROL DOCUMENT * 1.DATE 84304 PAGE 1 OF 1 PAGES

2.ORIG/PROD NR	3.QUANTITY	4.PROD SECTION/RCC	5.DATE SCHED	6.DATE COMP
13123A		MTPG9E		

7.PART NUMBER	9.ITEM SERIAL NR	8/12.TECH DATA/OPTIONAL
3810036-1		2G-GTCP36-3

10.MODEL/DESIGN/SERIES	11.STOCK NR
GTCP36-50	2835010123204

13.MISC	14.NOUN/END ITEM NOUN
	HOUSING INLET BSK #9 (85 FIG 3-3)

15.DISP- STATION	16.PDN/ OP NO.	17.WORK TO BE ACCOMPLISHED	18.MECH	19"P"	20"Q"
PSI6	010 MTPSI	VISUALLY INSPECT IAW PARA 5-64.1 AND 2	M		
	020	DIMENSIONALLY INSPECT IAW FIG 5-15 AND PARA 5-64.3	M		
	030	REPAIR BURRS, MINOR GALLING, IAW PARA 5-113 AND 5-144	M		
	040	PERFORM CIRCULAR RUNOUT IAW PARA 5-64.4.5	M		
	050	PERFORM MAGNETIC PARTICLE INSPECTION. IAW PARA 5-13 AND 5-64.6	N		
PSI6	060 MTPSI	REPLACE COMPRESSOR INLET HOUSING IF INSPECTION REQUIREMENTS ARE NOT MET. IAW PARA 5-64.7 ROUTE TO PARTS POOL	M		
		MATEA [illegible] 31 OCT 1984 OCT 31 1984 MAQT [illegible] MATSE [illegible] 31 oct 84 MTPSI [illegible] 2 Nov 84			

Appendix E

Bldg 329 Systems Implementation Plan

Contract No. F41608-86-C-A016 SwRI Project No. 14-8917

DATE		SYSTEM TITLE
28 MAY 86	+	Partial installation of MSAPIS (hosts, laser, 4 sta)
25 SEP 86	+	MSAPIS inspection system installation complete
01 OCT 86	*	Move elect/sheet metal shops out of new PP area
05 JAN 87	*	Move disassembly to new area
05 MAR 87	*	Relocate PP into new area
01 APR 87	*	Procure new cleaning line
10 JUN 87	*	Install auto inspection stations
01 JUL 87	*	B1B starter workload (13,438 sq ft)

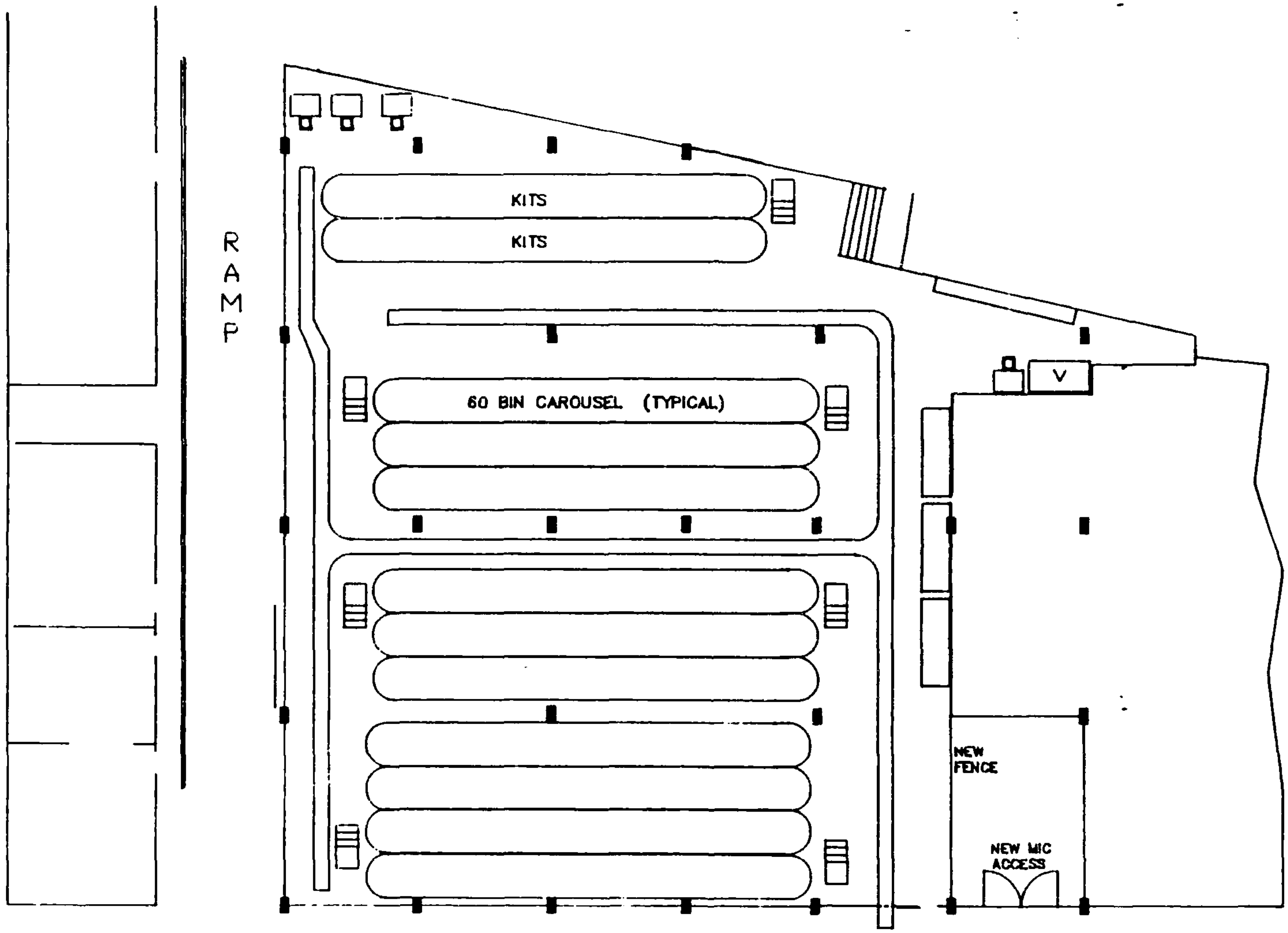
LEGEND:

+ Dates received from Manual Diago, MATEA

* Dates received form Mike Goos, MATEG

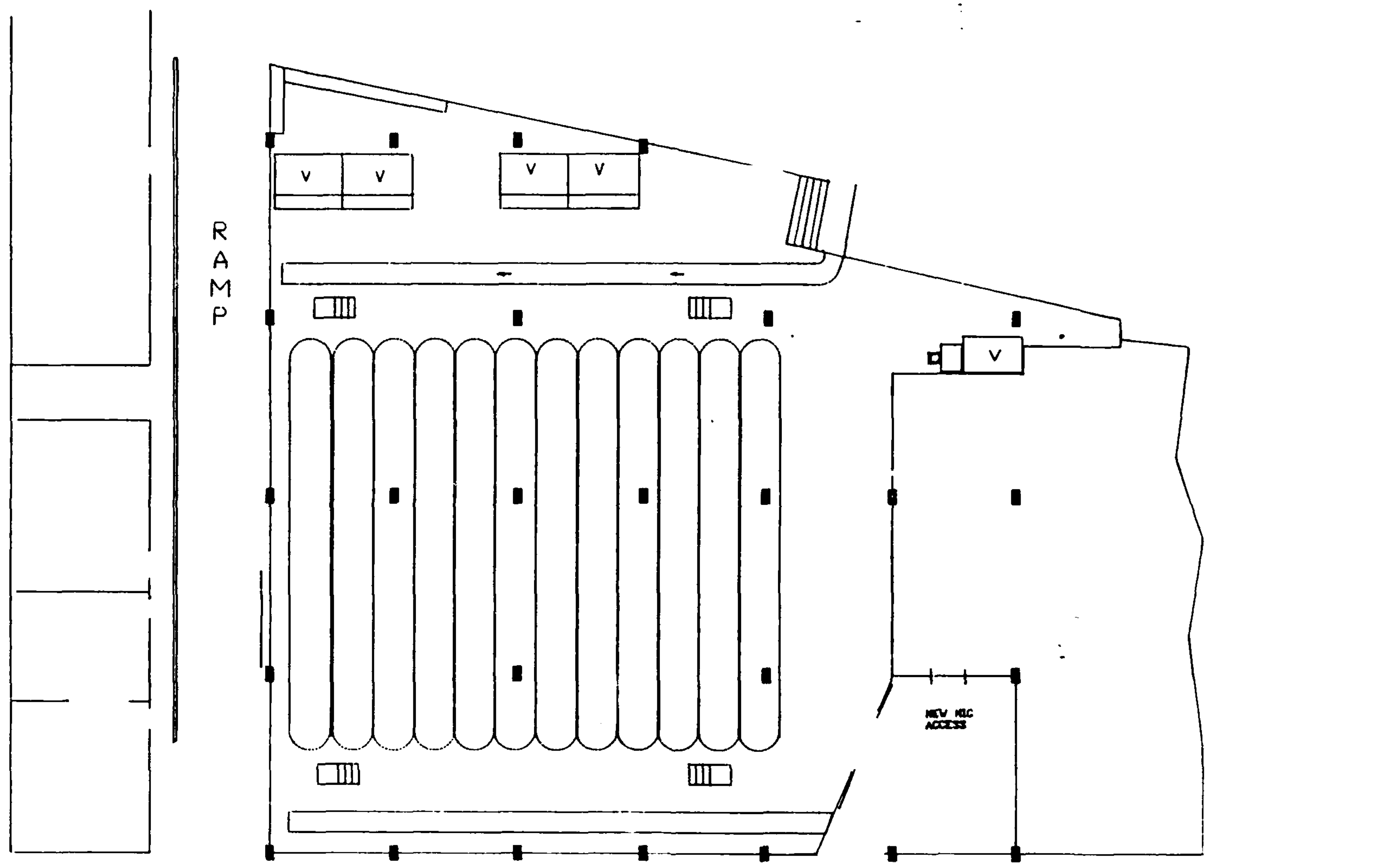
Appendix F

Parts Pool Layout Drawings



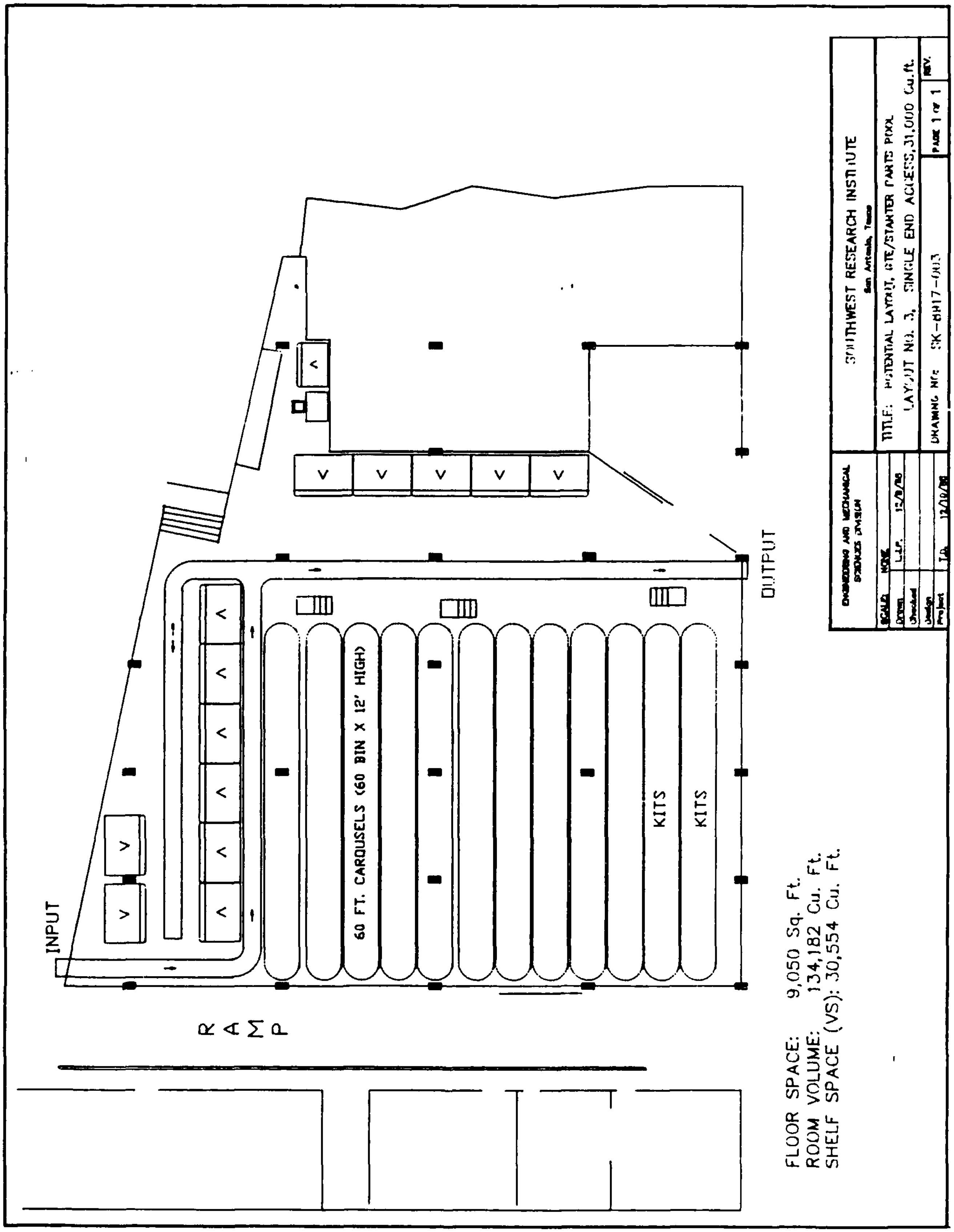
FLOOR SPACE: 9,050 Sq. Ft.
ROOM VOLUME: 134,182 Cu. Ft.
SHELF SPACE (VS) 27,911 CU. FT.

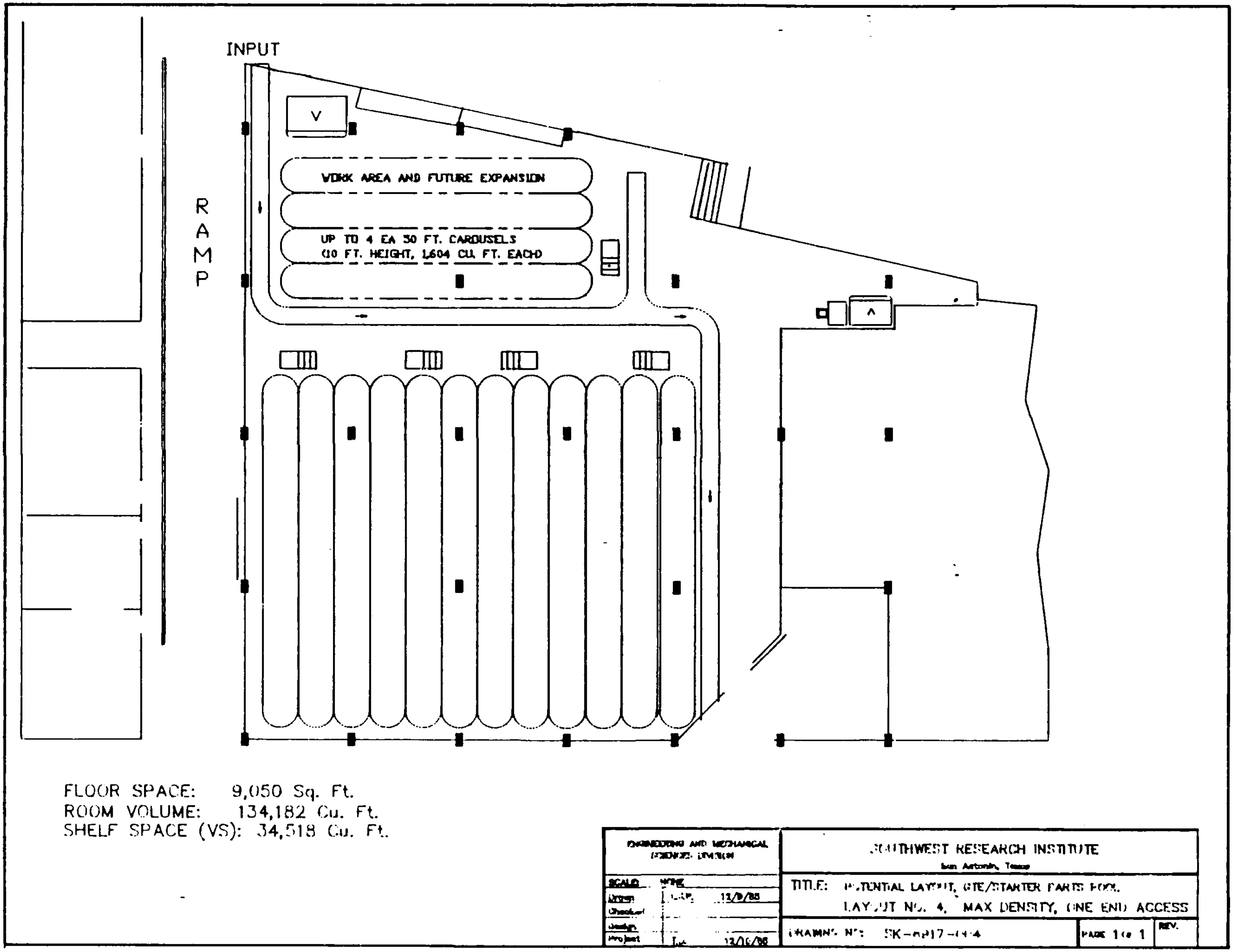
ENGINEERING AND MECHANICAL SCIENCES DIVISION			SOUTHWEST RESEARCH INSTITUTE San Antonio, Texas	
SCALE:	NONE		TITLE: POTENTIAL LAYOUT, GTE/STARTER PARTS POOL LAYOUT NO. 1, 28000 Cu.Ft. STORAGE SPACE	
Drawn	L.J.P.	12/8/88		
Checked				
Design			DRAWING NO: SK-6917-001	PAGE 1 OF 1
Project	T.D.	12/19/88		REV.

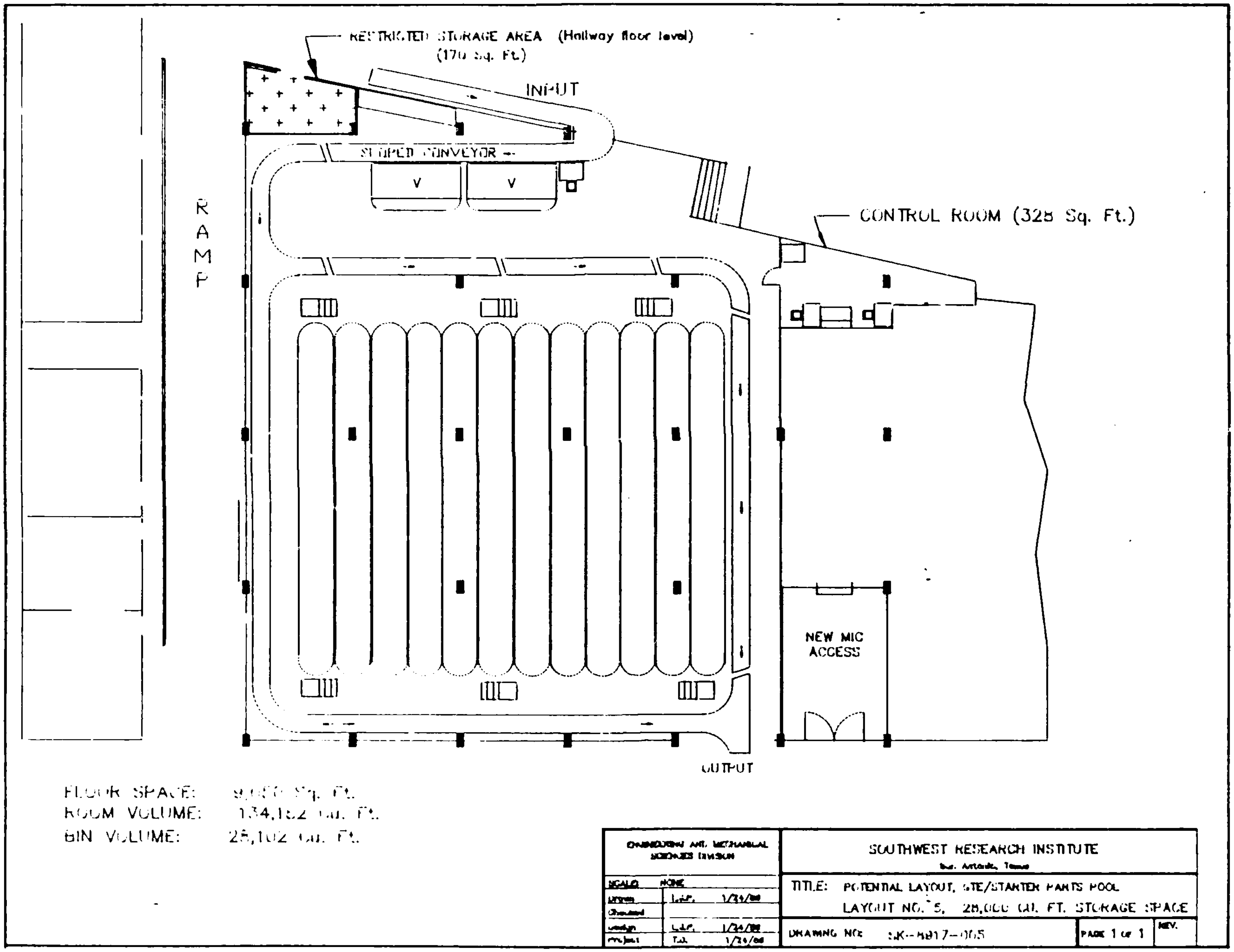


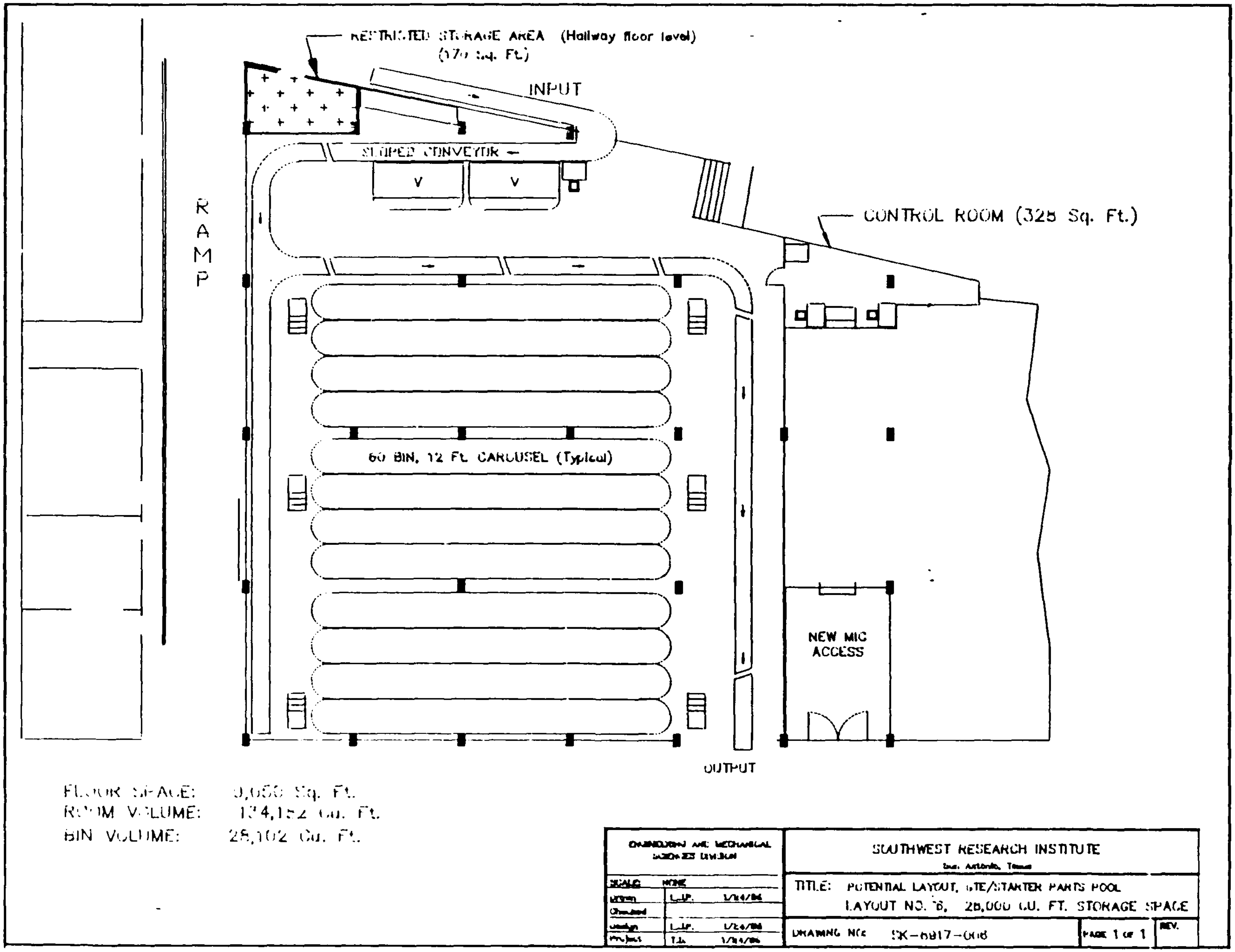
FLOOR SPACE: 9,050 Sq. Ft.
ROOM VOLUME: 134,182 Cu. Ft.
SHELF SPACE (VS): 28,875 CU. FT.

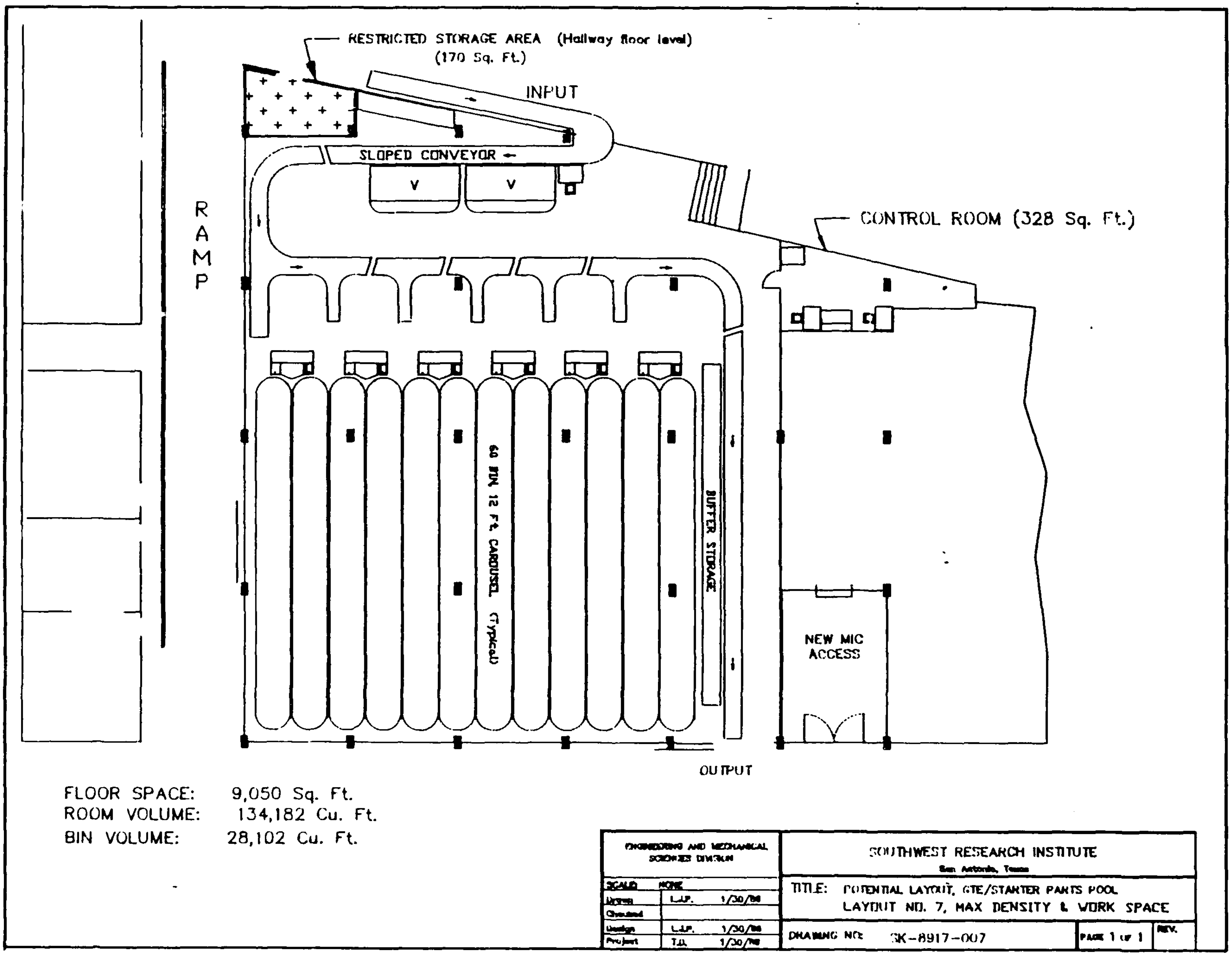
ENGINEERING AND MECHANICAL SCIENCES DIVISION	SOUTHWEST RESEARCH INSTITUTE San Antonio, Texas
SCALE: NONE Drawn L.L.P. 12/9/88 Checked Design Project T.B. 18/2/85	TITLE: POTENTIAL LAYOUT, GTE/STARTER PARTS POOL LAYOUT NO. 2, 29,000 Cu. Ft. STORAGE SPACE DRAWING NO: SK-8817-002 PAGE 1 OF 1 REV.


SOUTHWEST RESEARCH INSTITUTE
San Antonio, Texas
ENGINEERING AND MECHANICAL SCIENCES DIVISION
SCALE NONE
Drawn L.L.F. 12/8/88
Project T.A. 12/10/88
TITLE: POTENTIAL LAYOUT, GTE/STARTER PARTS PIXXL
LAYOUT NO. 3, SINGLE END ACCESS, 31,000 Cu.ft.
DRAWING NO. SK-8817-003
PAGE 1 OF 1
REV.
INPUT
OUTPUT
RAMP
60 FT. CAROUSELS (60 BIN X 12' HIGH)
KITS
KITS
FLOOR SPACE: 9,050 Sq. Ft.
ROOM VOLUME: 134,182 Cu. Ft.
SHELF SPACE (VS): 30,554 Cu. Ft.


INPUT
RAMP
WORK AREA AND FUTURE EXPANSION
UP TO 4 EA 30 FT. CAROUSELS
(10 FT. HEIGHT, 1,604 CU. FT. EACH)
FLOOR SPACE: 9,050 Sq. Ft.
ROOM VOLUME: 134,182 Cu. Ft.
SHELF SPACE (VS): 34,518 Cu. Ft.
ENGINEERING AND MECHANICAL SCIENCES DIVISION
SCALE NONE
SOUTHWEST RESEARCH INSTITUTE
San Antonio, Texas
TITLE: POTENTIAL LAYOUT, GTE/STARTER PARTS POOL
LAYOUT NO. 4, MAX DENSITY, ONE END ACCESS
PAGE 1 of 1
REV.


RESTRICTED STORAGE AREA (Hallway floor level)
(170 Sq. Ft.)
INPUT
SLOPED CONVEYOR
V
V
RAMP
CONTROL ROOM (328 Sq. Ft.)
NEW MIC ACCESS
OUTPUT
FLOOR SPACE:
ROOM VOLUME: 134,182 Cu. Ft.
BIN VOLUME: 25,102 Cu. Ft.
ENGINEERING AND MECHANICAL SCIENCES DIVISION
SCALE NONE
SOUTHWEST RESEARCH INSTITUTE
San Antonio, Texas
TITLE: POTENTIAL LAYOUT, GTE/STARTER PARTS POOL
LAYOUT NO. 5, 28,000 CU. FT. STORAGE SPACE
DRAWING NO: SK-8817-005
PAGE 1 OF 1
REV.


RESTRICTED STORAGE AREA (Hallway floor level)
INPUT
SLOPED CONVEYOR
RAMP
CONTROL ROOM (325 Sq. Ft.)
60 BIN, 12 Ft. CAROUSEL (Typical)
NEW MIC ACCESS
OUTPUT
FLOOR SPACE: Sq. Ft.
ROOM VOLUME: 134,152 Cu. Ft.
BIN VOLUME: 28,102 Cu. Ft.
SOUTHWEST RESEARCH INSTITUTE
San Antonio, Texas
TITLE: POTENTIAL LAYOUT, GTE/STARTER PARTS POOL
LAYOUT NO. 6, 28,000 CU. FT. STORAGE SPACE
DRAWING NO: SK-6817-008
PAGE 1 OF 1
REV.
SCALE NONE


RESTRICTED STORAGE AREA (Hallway floor level)
(170 Sq. Ft.)
INPUT
SLOPED CONVEYOR
V
V
RAMP
CONTROL ROOM (328 Sq. Ft.)
60 BIN, 12 Ft. CAROUSEL (Typical)
BUFFER STORAGE
NEW MIC ACCESS
OUTPUT
FLOOR SPACE: 9,050 Sq. Ft.
ROOM VOLUME: 134,182 Cu. Ft.
BIN VOLUME: 28,102 Cu. Ft.
ENGINEERING AND MECHANICAL SCIENCES DIVISION
SCALE NONE
Drawn L.J.P. 1/30/88
Checked
Design L.J.P. 1/30/88
Project T.D. 1/30/88
SOUTHWEST RESEARCH INSTITUTE
San Antonio, Texas
TITLE: POTENTIAL LAYOUT, GTE/STARTER PARTS POOL
LAYOUT NO. 7, MAX DENSITY & WORK SPACE
DRAWING NO: SK-8917-007
PAGE 1 of 1
REV.

ABBREVIATIONS

AFLC	Air Force Logistics Command
ALC	Air Logistics Center
AMAD	Aircraft Mounted Accessory Drive
AS/RS	Automated Storage/Retrival System
AWM	Awaiting Maintenance
AWP	Awaiting Parts
B-Job	Partial Overhaul Job
BOM	Bill of Material
CDRL	Contract Data Requirements List
CGB	Central Gearbox
CID	Carousel Interface Device
CPU	Central Processing Unit
CRT	Cathode Ray Tube (Computer Terminal)
DMICS	Depot Maintenance Integrated Communications System
DOD	Department of Defence
DS	Directorate of Distribution
DSS	Decision Support System
D033	Base Supply Data System
DWC	Digital Weight Counter
E/I	Evaluation/Inspection Shop
FPI	Flourescent Penetrant Inspection
GTE	Gas Turbine Engine
G046	MJT Data System Designation
G004L	MA Work Order Data System
HHLS	Hand Held Laser Scanner

IAW	In Accordance With
I/O	Input/Output
JFS	Jet Fuel Starter
JON	Job Order Number
LCB	Load Cell Base
LM	Directorate of Logistics Management
LOGMARS	Logistics Application of Automated Marking & Reading Symbols
MA	Directorate of Maintenance
MAB	Aircraft Division
MAE	Engine Division
MAT	Technology Repair Division
MAW	Resources Management Division
MCS	Material Control System
MDS	Model/Design/Series
MIC	Material Inventory Control
MIS	Management Information System
MJT	Maintenance Job Tracking
MPI	Magnetic Particle Inspection
MSAPIS	Multi-Station Auto Prompting Inspection System
NSN	National Stock Number
OCM	On Condition Maintenance
OPD	Obvious Physical Damage
OPR	Office of Primary Responsibility
OWO	On Work Order
PC	Personal Computer
POC	Point Of Contact
PP	Parts Pool

P/N	Part Number
RCC	Resource Control Center
RID	Robotic Interface Device
SA-ALC	San Antonio-Air Logistics Center
SAI	Satisfactory As Is
SOW	Statement of Work
S/R	Storage/Retrival
SPS	Secondary Power System
S/N	Serial Number
SwRI	Southwest Research Institute
TO	Technical Order
TWS	Tote Weighing System
WCD	Work Control Document
WIP	Work In-Process
WSL	Work Station/Lift

END
DATE
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